



HOKKAIDO UNIVERSITY

Title	MITULASPIS AND SCLOPETASPIS : THEIR DISTRIBUTIONS AND TAXONOMIC POSITIONS (HOMOPTERA : COCCOIDEA : DIASPIDIDAE)
Author(s)	TAKAGI, Sadao
Citation	Insecta matsumurana. Series entomology. New series, 47: 33-90
Issue Date	1992-10
Doc URL	http://hdl.handle.net/2115/9865
Right	
Type	bulletin
Additional Information	



Instructions for use

**MITULASPIS AND SCLOPETASPIS :
THEIR DISTRIBUTIONS AND TAXONOMIC POSITIONS
(HOMOPTERA : COCCOIDEA : DIASPIDIDAE)**

By SADAO TAKAGI

Systematic and Ecological Surveys on Some Plant-parasitic Microarthropods
in Southeast Asia, Scientific Report No. 14.

Abstract

TAKAGI, S. 1992. *Mitulaspis* and *Sclopetaspis* : their distributions and taxonomic positions (Homoptera : Coccoidea : Diaspididae). *Ins. matsum. n. s.* 47 : 33-90, 1 tab., 68 figs. (in 41 pls.).

Two genera of armoured scale insects distributed in Asia and Africa are examined. *Mitulaspis* has been represented by *M. funtumiae* occurring in Uganda and *M. malayana* in Malaya, but *M. funtumiae* is now recorded from Malaya. Therefore, *Mitulaspis* may be an Asian genus and *M. funtumiae* may have been introduced into Africa by human agency. However, a revision shows that the genus is a primitive lepidosaphedine, and this does not exclude the possibility that *Mitulaspis* is a relic in Asia and Africa. Two species of *Sclopetaspis* have been known from tropical Africa ; another species, *S. danumensis*, sp. nov., is described from Sabah. Based on the latter species *Sclopetaspis* is deemed to be rather primitive in the Diaspidini while it is peculiar in producing tubular wax filaments. It seems to be isolated taxonomically, and may be a relic. *Melayumytilus smilacis*, gen. et sp. nov., is described from Malaya and the 1st instar larvae of *Mitulaspis malayana*, *Melayumytilus smilacis*, *Howardia biclavis*, *Aonidomytilus albus*, *Andaspis crawii* and *Metandaspis javanensis* (new to Borneo) are compared in connection with the revision of *Mitulaspis*.

Author's address. Systematic Entomology, Faculty of Agriculture, Hokkaidō University, Sapporo, 060 Japan.

Contents. Introduction — Material — Major groups within the Diaspididae — A revision of *Mitulaspis* — An examination of *Sclopetaspis* — Conclusion — Records and descriptions [*Mitulaspis funtumiae* — *Mitulaspis malayana* — *Howardia biclavis* — *Melayumytilus smilacis*, sp. nov. — *Melayumytilus*, gen. nov. — *Metandaspis javanensis* — *Sclopetaspis danumensis*, sp. nov.] — Acknowledgements — Literature — Plates.

INTRODUCTION

In recent years I have been engaged in microarthropod surveys in Malaysia and obtained a large amount of scale insect material from a wide range of vegetation including mangroves, dipterocarp forests, heath forests, montane oak forests, high altitude scrub, and plantations. Preliminary examinations show the presence of a number of undescribed species, especially of the family Diaspididae, in the collection. Scale insects which have been known from Malaysia, and from Southeast Asia in general, are undoubtedly mere fragments from the fauna. In the tropics of the world this insect group, the superfamily Coccoidea, must embrace unknown species in a tremendous number.

Any view adoptable as to the scale insect fauna of Southeast Asia is, therefore, only tentative. It seems, however, that, so far as the family Diaspididae, the largest group in the Coccoidea, is concerned, the fauna is composed mainly of many genera distributed over a broad region including South Asia, Southeast Asia and temperate East Asia and various others probably endemic to Southeast Asia or tropical Asia; relatively few genera are more widely distributed. Above all, the fauna as represented by the collection is characterized by the dominance of *Pseudaulacaspis*, *Aulacaspis* and some other genera, which are also well represented in South Asia and temperate East Asia. In this regard all these areas of Asia are closely related faunistically.

Thus, so far as the diaspidid genera are concerned, tropical Asia may have no close faunal relation with the other tropical regions. Some relation may still be expected, especially between the tropical regions of Asia and Africa. But in my examinations of the collection from Malaysia I have only rarely come across genera which can be supposed to be common and peculiar to these regions. Because of their rarity, Asio-African genera, if any, would evoke our particular interest.

Mitulaspis was erected for *Chionaspis funtumiae* occurring in Uganda. Hall (1946) states that he 'was surprised to come across material of an undescribed species from Malaya... that is not only congeneric with *funtumiae* but extremely close to it'. The Malayan species was later described by Hall and Williams (1962) under the name *M. malayana*. I collected it in Malaya and Sarawak, and, quite unexpectedly, *M. funtumiae*, too, in Malaya. Now it is probable that *Mitulaspis* is an Asian genus, and that *M. funtumiae* was introduced to Africa by human agency. (In this connection it is interesting that in Uganda *M. funtumiae* was collected in Entebbe.) On this supposition the close similarity between the 2 species is no longer surprising. However, this discovery alone does not definitely eliminate the possibility that *M. funtumiae* is native to Africa (see under Conclusion).

Sclopetaspis has been represented by 2 species described from Uganda and Malawi. In this paper *S. danumensis* (sp. nov.) is described from Sabah. It is conspicuously different from the descriptions of the African species in some characters, but after my close examinations I have been convinced that it is best referred to *Sclopetaspis*. Considerable differences may usually be expected between congeneric species when they occur natively in disjunct remote areas. *S. danumensis* was collected in the primeval forest of the Danum Valley Conservation Area, 85 km distant from Lahad Datu and over 40 km apart from any other permanent habitation; I have no reason to suppose that it is an introduced insect. The 2 African

species are, so far as based on the descriptions, considerably similar to each other, thus supporting the view that they are native to Africa.

Borchsenius (1966) referred *Mitulaspis* to the Chionaspidina and grouped *Sclopetaspis* with other genera in the Sclopetaspidina (both these subtribes being placed under the Chionaspidini, the Diaspidinae, in his classification), but these groupings are problematical. Both the genera appear distinctive and isolated, thus requiring critical revisions as to their taxonomic positions.

MATERIAL

In this study material which had been preserved in dried condition was used for both light and scanning electron microscopy. [For the preparation of material, see Takagi (1992).] Probably owing to this the SEM photographs obtained, especially of disc pores, are generally not satisfactory, but they have been still useful for this study.

About half the specimens examined including the nominiferous specimens [holotypes] of the 2 new species described in this paper are deposited in the collection of the Entomology Division, Forest Research Institute of Malaysia, Kepong, Selangor, Malaysia, and the remaining specimens in the Laboratory of Systematic Entomology [formerly Entomological Institute], Faculty of Agriculture, Hokkaidō University, Sapporo, Japan.

MAJOR GROUPS WITHIN THE DIASPIDIDAE

In the view adopted here most species of the Diaspididae fall into 2 large divisions, which may be ranked as subfamilies, Diaspidinae and Aspidiotinae. The Diaspidinae are principally characterized by having gland spines and by the pygidial lobes bilobulate except the median pair. The Aspidiotinae have pectinae ('plates' in authors) instead of gland spines and their pygidial lobes are all unilobed. These appendages may be modified in state or secondarily lost. Primitive forms have no lobes primarily. In the Diaspidinae 2 main groups, the Diaspidini and the Lepidosaphedini, may be recognized. The Aspidiotinae include the Aspidiotini, Parlatoriini, Odonaspidini, Leucaspidini and other forms. Borchsenius (1966) proposed many subtribes in the Diaspididae, but in my view his classification at this category is largely confused. On the other hand, some evolutionary stages or levels may be recognized in the organization of the pygidial fringe. I have presented a simple scheme to show them (Takagi, 1990b: Table 1), setting up 4 major stages, Level 0–III, in 2 lines, Stock I and II. Stock I corresponds to the Diaspidinae and II to the Aspidiotinae, but primitive forms belonging to Level 0 may represent other subfamilies.

I (Takagi, 1990b) made SEM observations on the disc pores of some selected diaspidids. The perivulvar disc pores are 5-locular, with 5 septa dividing the space within the pore into 5 loculi. Some types are recognized on the basis of the shape of the septal processes. The species examined of the Diaspidinae all fall in one type, the capitate type, whereas those of the Aspidiotinae represent the other types. The spiracular disc pores are 3-locular in the Diaspidinae, while 5-locular in the Aspidiotinae. Exceptions are known: *Haliaspis* and some other forms of the

Diaspidini have 4-locular spiracular disc pores; *Microparlatoria*, having 3-locular ones, forms an exception to the Aspidiotinae. The septa of the spiracular disc pores are simple or more or less expanded to form processes.

Howell and Tippins (1990) divided the Diaspididae into 3 groups on the basis of the 1st instar. Their Group I corresponds to the Aspidiotinae (as here understood) and Group II to the Diaspidinae. The isolated form *Comstockiella* represents Group III.

A REVISION OF MITULASPIS

Hall (1946) states that *Balaspis*, erected by him for *B. faurei* occurring in South Africa, comes close to *Mitulaspis*, and it is the only possible close relative of *Mitulaspis* I have noticed. However, his figure shows that it is quite different in the arrangement of the pygidial macroducts. As will be shown, the 1st instar larva is essential to clarifying the taxonomic position of *Mitulaspis*. Because I have had no opportunity to examine *B. faurei* and especially its 1st instar, I will make no further mention of *Balaspis* in this paper.

Lindinger (1932) referred *Chionaspis funtumiae* to *Lepidosaphes* by reason of the unkeeled male test and the presence of a pair of gland spines between the median lobes. But the species does not fit in with the concept of *Lepidosaphes* as understood currently and even in his time. *Mitulaspis* is quite different from *Lepidosaphes*. However, in both species of *Mitulaspis* the 2nd to 4th abdominal segments are divided laterally to form a lateral tubercle on the base of each segment (Figs. 1 & 2), and this character supports the view that the genus belongs to the Lepidosaphedini. The 2nd instar male (Fig. 3), being similar in the pygidial fringe to the adult and 2nd instar females, does not contradict the view. If this genus really belongs to the Lepidosaphedini, it may be placed in the subtribe Coccomytilina owing to the absence of megaducts ['mégapores' in Balachowsky (1954)].

Disc pores. — The disc pores offer problems. The perivulvar disc pores of *M. malayana* are 5-locular as usual, but, in scanning electron microscopy, they are simple in the structure of the septa, lacking any processes (Figs. 28 & 29), and, thus, may be quite extraordinary in the family. [In the very primitive diaspidid *Ulucoccus*, too, the abdominal disc pores (not perivulvar in position) are simple in structure (Takagi, 1990b).] They are abducent in secreting wax cylinders (the material for this observation was not in good condition, and the photographs obtained are not presented here). On the other hand, perivulvar disc pores having septal processes are adducent in secreting wax cylinders (Takagi, 1990b). Furthermore, *M. malayana* has 5-locular spiracular disc pores, which are very similar to the perivulvar disc pores in structure (Fig. 30), in disagreement with the generalization that the spiracular disc pores are 3-locular in the Diaspidinae. However, the spiracular disc pores in the 1st instar are 3-locular (in light microscopy). (The spiracular disc pores in the 2nd instar male and female are 5-locular in light microscopy.) *M. funtumiae* has no perivulvar disc pores, but it does not differ from *M. malayana* in having 5-locular spiracular disc pores in the adult female and the 2nd instar male and female and 3-locular ones in the 1st instar (in light microscopy).

In connection with these problems *Howardia biclavis* and *Melayumytilus smilacis* (gen. et sp. nov.) should be mentioned, because these species also have 5-locular

spiracular disc pores (Figs. 31 & 32) in spite of the fact that otherwise they are referable to the Diaspidinae. In the 1st instar the spiracular disc pores are 3-locular in *H. biclavis* as in *M. malayana*, but 5-locular in *M. smilacis* (in light microscopy). When these disc pores are ignored, *M. smilacis* is referable to the Lepidosaphedini. *H. biclavis* has usually been referred to the Diaspidini, but Williams (1960) in describing another species, *H. stricklandi*, from Africa suggests that these species are lepidosaphedines. These species of *Melayumytilus* and *Howardia* have lateral spurs on the prepygidial abdomen. I think that the presence of lateral spurs or lateral tubercles on the prepygidial abdomen is a diagnostic character of lepidosaphedines. (However, this feature is found not in all lepidosaphedines.) Unfortunately, *H. biclavis* and *M. smilacis* have no perivulvar disc pores.

First instar. — Howell and Tippins (1990) state that *Howardia biclavis* shares a certain character with lepidosaphedines in the 1st instar. Comparisons are here made among the 1st instar larvae of *Mitulaspis malayana*, *Howardia biclavis*, *Melayumytilus smilacis*, *Aonidomytilus albus*, *Andaspis crawii* and *Metandaspis javanensis* (Figs. 5-10 & 18). So far as the adult females are concerned, *Aonidomytilus albus* (Fig. 24) and *Andaspis crawii* (Fig. 25) definitely belong to the Lepidosaphedini. *Metandaspis javanensis* (Fig. 26) is a somewhat odd form but may also belong to this tribe; its spiracular and perivulvar disc pores in scanning electron microscopy do not contradict this supposed position (Figs. 33 & 34). The 1st instar larvae of all these 6 species belong to 'Group II' (Howell and Tippins, 1990) by the absence of a submedian duct on the dorsum of 'abdominal segment 2' and also of a submarginal duct on the dorsum of head and mesothorax. The 1st instar of *Aonidomytilus albus* closely agrees with that of *Lepidosaphes ulmi* studied by Howell and Tippins (1976), differing from the latter in the 6th antennal segment annulate and in other minor details. *Melayumytilus smilacis* is similar to the 2 species above, but the lobes occurring just laterally to the caudal setae ('lobe 2' in Howell and Tippins, 1976) have a somewhat enlarged inner lobule. (It differs from all the other species examined in having 5-segmented antennae, and, as stated above, it is peculiar also in having 5-locular spiracular disc pores.) This lobule is much enlarged in *Mitulaspis malayana*, *Howardia biclavis*, *Andaspis crawii* and *Metandaspis javanensis*, apparently corresponding to the enlarged median lobes in the adult female and the 2nd instar. *M. malayana* is characterized by the head incised medially. *M. javanensis* differs from all the other species examined by lacking gland spines (except at the posterior end of the body).

In spite of all these differences the species examined agree in 'the presence of a seta on the tarsus behind the base of the claw' (Howell and Tippins, 1990). The presence of this seta may be adopted as a stable character of the lepidosaphedines when these are compared with the Diaspidini. However, it is noteworthy that this character is found in the Aspidiotinae, too. The Lepidosaphedini and the Aspidiotinae are also commonly characterized by the presence of 2 apical (or 1 apical and 1 subapical) setae on the terminal antennal segment. In consideration of this, the occurrence of 5-locular spiracular disc pores in *Mitulaspis*, *Howardia* and *Melayumytilus* may not be surprising, and can be interpreted as another 'aspidiotine character' held by some lepidosaphedines.

Taxonomic position. — All this supports the view that *Mitulaspis* belongs to the Lepidosaphedini. This genus, however, finds no particularly close relatives in the

tribe. Some of its characters can be interpreted as primitive : in the 2nd instar and adult female the antennae are multisetose, the pygidial lobes are represented by 3 pairs all well developed and all substantially same in shape, with the median ones well separated from each other, and the marginal macroducts of the pygidium are not completely differentiated, having no associated pore prominences mesally to the lobes (Figs. 1-3, 15-17 & 19). The perivulvar disc pores are simple in structure, and abducent in secreting wax cylinders. On the other hand, the enlarged median lobes (and the corresponding large lobule just outside the caudal setae in the 1st instar) are derivative. Apparently, as a whole, *Mitulaspis* can be regarded as a primitive lepidosaphedine.

Mitulaspis may be referred to 'Groupe II' of lepidosaphedines or 'espèces à mégapores absents' (Balachowsky, 1954). Also *Howardia* is now a lepidosaphedine and is referable to 'Groupe II' by lacking megaducts. The names *Coccomytilina* Borchsenius (1965) and *Howardiina* Borchsenius (1965) are available for this group and, thus, synonyms. I would like to adopt *Coccomytilina*, because this name was originally proposed under the *Lepidosaphedini*, whereas *Howardiina* under the *Diaspidini* (as understood in a much narrower sense than adopted in this paper). Furthermore, it seems that all of the other genera referred to the *Howardiina* by Borchsenius (1966) are not lepidosaphedines.

The *Coccomytilina* now include diverse forms. It is open to question whether 'espèces à mégapores absents' form a phylogenetic group or not. The absence of megaducts may be a primitive character, but the possibility cannot be excluded that this state is also due to a secondary loss or reduction (in size) of megaducts.

The phylogenetic relation between the *Lepidosaphedini* and the *Diaspidini* is also to be clarified. *Megacanthaspis* and *Nikkoaspis* represent early evolutionary stages, Level I and II, in the organization of the pygidial fringe and may be regarded as primitive *Diaspidini*. However, their perivulvar disc pores, having well-developed capitate septal processes, do not differ from those of advanced *Diaspidini* (Takagi, 1990b). Now that *Mitulaspis* is a primitive lepidosaphedine, it may be compared with *Megacanthaspis* and *Nikkoaspis*. However, in this comparison *Mitulaspis* is more advanced in the state of the pygidial appendages, almost corresponding to Level III (but without distinct pore prominences), whereas it probably represents a primitive state of perivulvar disc pores. It is, therefore, still unknown how these tribes are related to each other. Furthermore, the presence of 'aspidiotine characters' in the tribe *Lepidosaphedini* throws doubt on the validity of its inclusion under the *Diaspidinae*. A possible solution may be the removal of the lepidosaphedines to their own subfamily, but our knowledge is still too meagre to justify the subfamily *Lepidosaphedinae*.

Adult male. — Ghauri (1962) made a detailed study on the adult males of some diaspidids including 2 lepidosaphedines, *Lepidosaphes ulmi* and *L. machili*. A few specimens of the adult male of *Mitulaspis malayana* have been examined (they were prepared after the same method as with other stages and mounted with fragments of cover-glass aside). This species does not agree with *Lepidosaphes* in some characters, especially of the head: midcranial ridge reduced; postoccipital ridge delicate and slender, and not produced posteriorly into a median process; preocular ridge not extended medially; preoral ridge present; prescutum transverse; no scutellar setae; etc. Do these characters indicate that *Mitulaspis* is not a lepidosa-

phedine or that it is a primitive lepidosaphedine? At present our knowledge is too meagre to answer these questions.

Tests. — The female test is fairly broad and the male one is much narrower, whereas the adult female and the 2nd instar male are not much different in body shape. No definite running direction of wax filaments can be recognized on the dorsal surface. However, filaments on the inner surface, especially of the female test, show a tendency to transverse running, thus suggesting some oscillatory movements of the insect in forming the test. I take this opportunity to present some SEM photographs of the tests, together with those of the female tests of *Melayumytilus smilacis* and *Metandaspis javanensis* (Figs. 37-53), other coccomytilines, because no SEM photographs of tests taken at high magnification have been published in the Lepidosaphedini. I hope that a meaningful comparison will be made in future on the basis of more lepidosaphedines.

Addendum. — At the conclusion of this section the variability of disc pores should be mentioned. *Mitulaspis* and *Howardia biclavis* show an ontogenetic change of the 3-locular type of spiracular disc pores to the 5-locular. *Microparlatoria itabicola* has 3-locular spiracular disc pores in spite of its position in the Parlatoriini (Takagi, 1990b), and suggests an evolutionary change from the 5-locular to the 3-locular type. These types of spiracular disc pores, therefore, may easily be changeable in both directions. However, it seems that still usually these pores are 3-locular in the Diaspidinae and 5-locular in the Aspidiotinae. In my scanning electron microscopy I came across some teratisms of perivulvar disc pores, a 3-locular one in *Lopholeucaspis japonica* (Takagi, 1990b: Fig. 36) and a 7-locular one in *Chionaspis alnus* to give a few examples. But the perivulvar disc pores are normally 5-locular throughout the family. (The very primitive genus *Uluccoccus* has 3- or 4-locular disc pores on the abdomen, but these pores are not perivulvar in position.) Apparently the number of loculi in the spiracular and perivulvar disc pores is considerably stable and only exceptionally variable. Our knowledge is, however, still meagre as to exceptional cases and not sufficient for a proper understanding of their significance in evolution and taxonomy.

AN EXAMINATION OF SCLOPETASPIS

Borchsenius (1965) erected the subtribe Sclopetaspidina, and later (1966) referred to it a total of 9 genera. Munting (1970) in his description of *Sclopetaspis malawica* ('malawicus') states that '*Sclopetaspis* might possibly fit better' in the subtribe Augulaspidina, which, according to Borchsenius (1966), comprises 11 genera. The nominifers [type-species] of all these genera including *Sclopetaspis* are known to me only through literature. However, so far as based on my observations on *S. danumensis* (sp. nov.), *Sclopetaspis* seems to be an isolated genus, probably having no particular relation with the other genera referred by Borchsenius to the Sclopetaspidina and also with the genera of his Augulaspidina.

S. danumensis belongs to the Diaspidinae in the general characters of the adult female. The spiracular and perivulvar disc pores in scanning electron microscopy do not contradict this position (Figs. 35 & 36). In the characters of the 1st instar (Fig. 14) it is definitely referable to the Diaspidini. The 2nd instar (Figs. 12 & 13) shows considerable sexual differences in the pygidial fringe; the sexual dimorphism

is, however, not so much remarkable as in many other Diaspidini (chionaspidines, floriniines, etc.). *S. danumensis* is almost referable to Level III in the organization of the pygidial fringe. At this level, however, it is relatively primitive. In the adult female (Figs. 11 & 27) the median lobes appear to be set close owing to their extended inner bases. But in the 2nd instar all the pygidial lobes are widely separated from each other and are little or only a little differentiated in shape among them; in the 2nd instar male they are well developed in as many as 6 pairs. In all these stages there are conical processes on the pygidial margin and some of them may be pore prominences, but no marginal macroducts are recognized. It is not decided whether the absence of marginal macroducts in this species is primary or secondary.

The tests of both sexes (Figs. 54-67) are especially noteworthy. They are composed of wax filaments which are not flattened but round in cross section and tubular; these filaments may be called 'wax tubes'. The adult female and the 2nd instar male and female have ducts of the geminate-pore type in addition to 2-barred ducts. However, the ducts of the former type are limited to the dorsal side of the prosoma, and should not be responsible for the production of the wax tubes, which are abundant both dorsally and ventrally. It seems, therefore, that the wax tubes are produced by the 2-barred ducts, but these ducts do not appear to be different from the usual 2-barred ducts (which produce ribbonlike wax filaments) in structure so far as observed in routine taxonomic mounts. The ducts of the geminate-pore type on the prosoma may produce wax cylinders (which should be solid internally), but I could not identify their production.

The formation of wax tubes is quite new to my knowledge, and I am puzzled over its meaning. The very primitive diaspidid *Uluccoccus*, which belongs to Level 0, has geminate-pore type ducts only and produces wax cylinders (Fig. 68). The wax tubes may represent a transitional stage in the evolutionary change from the wax cylinders to the ribbonlike wax filaments. But even *Megacanthaspis* and *Nikkoaspis*, primitive genera at Level I and II, produce ribbonlike filaments (Takagi, 1990a). If the wax tubes are really transitional between the wax cylinders and ribbonlike wax filaments, then the conclusion adoptable is that *Sclopetaspis* has evolved almost to Level III in the organization of the pygidial fringe while staying at the transitional stage in the secretion of wax. But I have no evidence in support of this discordance of characters. Then the possibility cannot be excluded that the formation of wax tubes is a specialized character and that *Sclopetaspis* represents a side branch off the main stocks of the family. It should be emphasized here that our knowledge as to diaspidid wax filaments is still very meagre. Any speculation, therefore, would turn wrong at a simple finding.

As to the female test of *S. laniger*, Newstead (1920) states that it is '*composed, externally, of white felted woolly material*' (his italics) and that 'Exuviae completely covered dorsally with dense loose woolly filaments'. The same is almost true for *S. danumensis*. It is probable but to be ascertained that the wax filaments of *S. laniger* (and also of its close relative *S. malawica*) are also tubular.

CONCLUSION

Kozár (1990) made a zoogeographical analysis of the Diaspididae on the supposi-

tion that the family is the most studied group in the Coccoidea. However, unknown species must far exceed the known ones in the tropical regions, and some recent works have shown that our concepts of described genera are often superficial and sometimes confused. The classification of this insect group is still far from complete and sound. Nevertheless, I am much inclined to agree with Kozár in his view that the main tropical regions of the world have been centres of diaspidid evolution largely independent of each other. This geographical diversification was started, according to him, with a considerable differentiation of the family in Gondwana. His analysis also shows that each of the main tropical regions is more or less related to the neighbouring northern temperate region; this may be due to expansions of some genera from the tropical to the temperate region. Genera commonly occurring in the main tropical regions, therefore, may be relics; otherwise, their present distributions may be due to occasional expansions.

The 2 species of *Mitulaspis* were described from Africa and Asia, respectively, but the supposed disrupted distribution is now open to doubt. Formerly *Africaspis* was supposed to occur also in Asia, but this supposition, too, proved to be erroneous (Takagi, Tho and Khoo, 1988). In spite of all this, the view is here adopted that *Sclopetaspis* is native to both regions. This unusual common occurrence requires explanation. This genus is referable to the Diaspidini, but seems to be isolated and rather primitive in morphological characters and is quite extraordinary in producing wax tubes. To go further is a matter of speculation, but I am inclined to believe that the genus is an escape out of many experiments attempted in the course of diaspidid evolution. This supposition is harmonious with the view that 'disparity' followed by 'diversity' in a limited number of disparate forms is a general pattern of evolution ['disparity' means range of anatomical design and 'diversity' number of species, according to Gould (1991)].

Mitulaspis seems also to be isolated, and is deemed to be a primitive lepidosaphedine. If this view is correct, the possibility that it is native to both Asia and Africa as a relic may not be completely eliminated. *M. funtumiae* may be native to Africa and may have been introduced to Malaya. Can we even flatly deny the possibility that this species is native to both Asia and Africa? The question here is whether an organism or closely related organisms when separated in remote areas can remain without any substantial morphological change for millions of years. 'Living fossils' are known in many groups of organisms, and sometimes closely related forms of them are found in remote areas (Eldredge and Stanley, eds., 1984). However, in the present status of studies on the Diaspididae, we can only expect to obtain further pieces of circumstantial evidence for or against the supposed introduction of *M. funtumiae* to Africa by human agency.

RECORDS AND DESCRIPTIONS

Abbreviations. L1: median lobe; L2: 2nd lobe; L2a: inner lobule of 2nd lobe; L2b: outer lobule of 2nd lobe; L3: 3rd lobe; L3a: inner lobule of 3rd lobe; L3b: outer lobule of 3rd lobe; abd I-VIII: 1st to 8th abdominal segments.

Mitulaspis funtumiae

Newstead (1913: 310) [*Chionaspis*; Entebbe, Uganda, on *Funtumia latifolia*]; MacGillivray

(1921 : 358) [*Mitulaspis* erected for *Chionaspis funtumiae*]; Lindinger (1932 : 200) [*Lepidosaphes*]; Ferris (1936 : 25 & 69) [*Mitulaspis* : 'Certainly valid as far as its separation from *Chionaspis* is concerned'; *M. funtumiae* illustrated : adult female, pygidium of 2nd instar female, and head and antenna of 1st instar]; Hall (1946 : 525) [diagnosis of *Mitulaspis* based on *M. funtumiae*]; Hall and Williams (1962 : 26) [*M. malayana* compared with *M. funtumiae*].

Material examined. Collected on Gunong Jerai, Kedah, Malaya, at an altitude of 930 m, on *Gaertnera vaginans* [Rubiaceae], Nov. 6, 1991 [91ML-344]. Occurring on the petioles and twigs of the host.

Adult female (based on 8 specimens mostly not in good condition). Body elongate, fusiform, attaining 2.6 mm long and 1.3 mm wide at maximum in mounted specimens; membranous, pygidium with a sclerotized pattern medially on dorsum. Head narrowing anteriorly; lateral margins of meso- and metathorax and abd I-IV produced, II-IV with a membranous process [lateral tubercle] anteriorly (a similar process is recognized at the anterolateral angle of the pygidium [abd V]); pygidium broadly roundish on margin. Anus situated toward base of pygidium. L1s prominent, separated from each other by a space narrower than one of them, parallel or a little divergent, each lobe obconical, blunt apically, minutely serrate on lateral margins, basally with a pair of sclerites converging anteriorly. L2 much smaller, but well developed; L2a similar to L1 in shape, basally with a pair of sclerites; L2b smaller and narrow. L3 a little smaller than L2, L3b very small. Antennae widely separated from each other, each being a low tubercle with 4 curved setae. Spiracular disc pores 5-locular, 7-13 associated with anterior spiracle and 3-5 with the posterior. Perivulvar disc pores absent. Tubercular spines occurring submarginally on ventral surface as follows: 1-4 on prothorax, at anterior end of a group of small ducts; 6-10 on mesothorax in a transverse row, with many small ducts and macroducts strewn just anteriorly and laterally; 13-19 on metathorax in a transverse row between posterior spiracle and lateral margin, with many small ducts and macroducts anteriorly and laterally; 15-22 on abd I within lateral margin. Slender marginal gland spines occurring as follows: abd II-V each with 1 (at times 2) on apex of lateral tubercle and with 3 or more posteriorly to lateral tubercle (II with 3-6, III and IV with 3-5, and V with 3 or 4); 2 laterally to L3; 3 between L2 and L3, the outermost much shorter; 2 between L1 and L2, the outer much shorter; 2 between L1s. Dorsal macroducts strewn in a broad marginal-submarginal region through abdomen and also on meso- and metathorax, abundant on abdomen; also occurring submedially on abd II-VI: 4-6 on II, 4-8 on III, 7-12 on IV, and 7-11 on V (on VI submedian macroducts confluent with submarginal ones); macroducts occurring in a broad apical region of pygidium somewhat larger than others; marginal macroducts not well differentiated, but usually there are 6 marginal macroducts on each side of the pygidium: 1 just mesad of base of L2a, without associated pore prominence, 2 on base of L3, with no pore prominence mesally to L3a, 2 in next space and 1 toward base of pygidium; no marginal macroduct between L1s.

Second instar female (exuvial cast). Attaining 1.1 mm in length and 0.8 mm in width; head attenuated anteriorly, while postsoma broadly rounded. Pygidial fringe similar to that of adult female, but marginal gland spines single between L1 and L2 and laterally to L3. Marginal macroducts single, occurring on abd I-VII; submarginal macroducts few; submedian macroducts absent.

Second instar male. Similar to adult female, with macroducts and gland spines

fewer but well represented ; submedian macroducts on abd II-VI. Anterior spiracle with 2-5 disc pores, the posterior with none. Marginal gland spines single between L1 and L2 and laterally to L3.

Remarks. The adult females examined substantially agree with the published descriptions and figures. They differ in having 3 gland spines, instead of 2, between L2 and L3, but the outermost of these spines is much shorter than the others. They also differ in having more numerous spiracular disc pores. In the figure drawn by Ferris (1936) the pygidium is provided with more numerous marginal macroducts. His figure may not be exact, because the marginal macroducts are not well differentiated and may be confused with neighbouring submarginal macroducts.

Figures. 1 [adult female], 15, 16 [adult female: pygidium].

Mitulaspis malayana

Hall and Williams (1962: 23) [Kuala Lumpur, Malaya, on *Cinnamomum camphora* and *C. zeylanicum*].

Material examined. Collected in the grounds of the Forest Research Institute of Malaysia, Kepong, Selangor, Malaya, on *Cinnamomum iners* [Lauraceae], June 17, 1990 [90ML-21]; on Bukit Bauk, Daerah Dungun, Terengganu, Malaya, on *Lophopetalum floribundum* [Celastraceae], Aug. 10, 1990 [90ML-461]; at Tasek Cini, Pahang, Malaya, on *Lophopetalum floribundum*, Aug. 13, 1990 [90ML-486]; in Taman Negara Bako [Bako National Park], Bahagian Kuching, Sarawak, on *Dehaasia incrassata* [Lauraceae], Oct. 14, 1991 [91ML-170]. Occurring on the petioles and twigs, and sometimes also on the leaves.

Adult female. Differs from *M. funtumiae* by the body ovate to broadly ovate, attaining about 1.6 mm in length in mounted specimens. Lateral margins of meso- and metathorax and abd I-IV produced only gently. Antenna with 5 or 6 setae. Perivulvar disc pores present, in 5 groups not well defined, the median group usually represented by an irregular transverse row of disc pores often confluent with the anterolateral groups; 13-30 in total. Marginal gland spines of abd II-V rather short, often absent on lateral tubercles; 2 between L2 and L3. Macroducts occurring in a broad apical region of pygidium not especially larger than others; 1 marginal macroduct usually present between bases of L1s.

The specimens collected from Sarawak [91ML-170] are different from the others examined in having extra disc pores at the posterior spiracles and in the constant presence of submedian macroducts on abd I. In these specimens the posterior spiracle has a group of 6-20 disc pores at the usual position and 1-5 satellite pores mesally, and often also 1-3 laterally, to the usual group. Otherwise the specimens from Sarawak are not especially different from the others, and all the specimens examined broadly overlap in the numbers of macroducts, disc pores and gland spines (Table 1).

Second instar female (exuvial cast). Rounded, attaining 0.9 mm in length and 0.8 mm in width. Submarginal macroducts more numerous than in *M. funtumiae*; submedian macroducts often present. Marginal gland spines single between L1 and L2, between L2 and L3, and laterally to L3.

Second instar male. Similar to adult female, with macroducts and gland spines fewer. Anterior spiracle with 2-5 and the posterior with 1 or 2 disc pores.

Table 1. Numbers of some external secretory organs in adult females of *Mitulaspis malayana*.

Material No.	90ML-21	90ML-461	90ML-486	91ML-170
Spiracular disc pores				
Anterior	5-13 (9.40±0.49)	4-12 (8.26±0.39)	8-18	5-19 (10.70±0.71)
Posterior	1-10 (6.46±0.40)	4-10 (6.60±0.66)	4-14	9-24 (15.36)
Perivulvar disc pores	13-24 (17.86±0.98)	14-26 (20.63±1.14)	18-30	14-27 (21.76±1.12)
Submedian macroducts				
Abd I	0	0	0- 2	2- 9 (4.88)
Abd II	0- 8 (3.25±0.56)	0- 4 (1.36±0.32)	1- 5	2- 9 (5.78±0.36)
Abd III	0-11 (5.33±0.42)	1- 6 (3.66±0.31)	2- 7	2-11 (6.26±0.50)
Abd IV	5-14 (9.18±0.54)	2- 8 (4.46±0.39)	4-11	3-10 (7.08±0.43)
Abd V	5-10 (7.35±0.29)	1- 7 (4.78±0.27)	5- 9	3-10 (6.73±0.36)
Gland tubercles				
Prothorax	3- 8	1- 8	0- 6	5-11
Mesothorax	6-12	4-11	4-11	4-12
Metathorax	8-13	6-13	6-13	2-18
Abd I	3- 9	4-10	1-10	8-16

Number of specimens examined : 30 for 90ML-21, -461, and 91ML-170 each (therefore, $n = 30$ for perivulvar disc pores, 60 for the other organs); 14 for 90ML-486, but counting was not complete in some specimens. Mean or mean±2S.E. in parentheses. Posterior spiracular disc pores for 91ML-170 include satellite ones (disc pores in the main group : 6-20, mean 12.45). Gland tubercles were not always exactly counted owing to the presence of ill-developed tubercles.

Submedian macroducts present on II(III)-VI [I(II)-VI in 91ML-170]. Gland spines single between L1 and L2, between L2 and L3, and laterally to L3. Three pairs of small pointed tubercles, with several setae around, on ventral surface of thorax, probably representing vestigial legs.

Remarks. The 2 species of *Mitulaspis* are much different in the body shape of the adult female: *M. funtumiae* is of the usual lepidosaphedine type, while *M. malayana* is broadly obovate. *Howardia*, another unusual lepidosaphedine genus, also exhibits this dimorphism (Williams, 1960 ; Williams and Watson, 1988).

Figures. 2 [adult female], 17, 19 [adult female : pygidium], 20 [adult female : posterior spiracle], 28, 29 [adult female : perivulvar disc pores], 30 [adult female : spiracular disc pore], 3 [2nd instar male], 5, 18 [1st instar larva], 37-40 [female test], 41-45 [male test].

Howardia biclavis

Comstock (1883 : 98) [*'Chionaspis (?)'* ; 'in the conservatory of the Department of Agriculture', on *Diospyros* and 4 other plants]. Recorded and redescribed from a long list of plants in the tropics and subtropics of the world.

Material examined. Collected at Keningau, Sabah, on *Dichapetalum* cf

gelonioides [Dichapetalaceae], Nov. 9, 1988 [88ML-289] ; on Banjaran Crocker, near Tambunan, Sabah, at an altitude of about 1,000 m, on *Ficus chrysocarpa* [Moraceae], Nov. 10, 1988 [88ML-306] ; in the grounds of the Forest Research Institute of Malaysia, Kepong, Selangor, Malaya, on *Phaeanthus ophthalmicus* [Annonaceae], June 27, 1990 [90ML-71]. Occurring on the branches. No male scales have been found.

On this occasion the specimens at hand from India should also be recorded : Collected at Coonoor, Nilgiri, Tamil Nadu, at an altitude of 1,600 m, on an undetermined plant (Verbenaceae?), Nov. 29, 1978 [78IND-242] (1 adult female, together with an aspidiotine species) ; at Mettupalayam View, Nilgiri, at an altitude of about 1,000 m, on roots exposed on a cliff (plant species unknown), Nov. 30, 1978 [78IND-255] ; at Thekkady (Periyar Sanctuary), Kerala, at an altitude of 920 m, on *Vateria indica* [Dipterocarpaceae], Dec. 9, 1978 [78IND-395] (1 adult female, together with *Rutherfordia major*).

Figures. 21 [adult female : pygidium], 31 [adult female : anterior spiracular disc pores], 6 [1st instar larva].

Melayumytilus smilacis, sp. nov.

Material examined. Collected in the grounds of the Forest Research Institute of Malaysia, Kepong, Selangor, Malaya, on *Smilax* sp. [Liliaceae], Nov. 1, 1986 [86ML-378] ; at Kuala Dungun, Terengganu, Malaya, on *Smilax* sp., July 19, 1990 [90ML-269]. Occurring under the stipules. Tests of female and male coriaceous and dark brown, similar to those of some species of *Lepidosaphes*. Nominiferous specimen [holotype] : adult female, mounted from 86ML-378.

Adult female (based on more than 20 specimens mounted from 86ML-378 and 13 from 90ML-269, not all of them being in good condition). Body oblong, attaining to about 1.5 mm in length and 0.6 mm in width ; at maturity head, thorax and abd I forming a thickly sclerotized region, occupying about 2/3 body length, and with no trace of segmentation marginally ; pygidium broad, dorsal surface tending to be irregularly reticulate about middle. Abd II-IV with a lateral tubercle, which is sclerotized into a spur on the posterior margin and bears a macroduct at the apex. Anus situated toward base of pygidium. L1s parallel, separated from each other by a space wider than one of them, each lobe robust, coarsely serrate on lateral sides, and broadly rounded apically. L2a similar to L1 in shape, but smaller ; L2b represented by a small conical process ; pygidial margin laterally to L2 rugged with robust prominences, among which the supposed L3a is well sclerotized. Abd II-IV each with a sclerotized conical process (corresponding to pygidial lobes?) at posterolateral corner. Antennae widely separated from each other, each being a low tubercle with 4 setae, which are subequal in length. Spiracular disc pores 5-locular, 3-13 associated with anterior spiracle and 3-10 with the posterior. Perivulvar disc pores absent. Margin between L1s a little recessed, with a pair of marginal gland spines ; 1 gland spine, usually with another much smaller one, just laterally to L1 and also to L2 ; usually 2 gland spines, often with another much smaller one, on preceding 4 segments (abd III-VI). Many microducts on ventral surface of prepygidial segments ; on thoracic segments some submarginal microducts are often associated each with a minute spine. Macroducts strewn on dorsal surface of pygidium and

within margin on prepygidial segments; marginal macroducts of pygidium not completely differentiated: there are on each side at least 4 marginal macroducts each opened in a pore prominence; submedian dorsal macroducts not clearly distinguishable from submarginal ones on abd VI and VII, 1-5 on V, and 0-2 on IV.

Second instar female. Similar to adult female, but with much fewer external secretory organs. Antenna with 4 setae. Anterior spiracle with 2 or 3 5-locular disc pores; posterior spiracle with none. Tubercular gland spines 1 or 2 on mesothorax, 2 on metathorax, 2 or 3 on abd I, and 1 or 2 on II; marginal gland spines 2 on III-V each, 1 laterally to L1-L3 each, 2 between L1s. A conical sclerotized process (corresponding to pygidial lobes?) at posterolateral angle of abd II-IV each. Lateral spurs well represented on abd II-IV, serrate, each with a macroduct. Marginal macroducts 4 on each side of pygidium, all single, opened in a marginal prominence. Submarginal macroducts few on abd IV-VI and also on prothorax to Abd I; 1 submedian macroduct on VI. Exuvial cast obovate, attaining about 0.8 mm in length and 0.6 mm in width.

Second instar male. Similar to the 2nd instar female. Anterior spiracle with 1 or 2 disc pores. Tubercular gland spines 1 (rudimentary) on mesothorax, 1 or 2 on metathorax, 2 or 3 on abd I, and 1 on II and III each; marginal gland spines 1 on IV-VIII each, 2 between L1s. Lateral spurs and conical marginal processes indistinct on abd II-IV. Submedian macroducts 1 or 2 on abd V, 1 on VI.

Figures. 4, 23 [adult female], 22 [adult female: pygidium], 32 [adult female: posterior spiracular disc pores], 7 [1st instar larva], 46-48 [female test].

Melayumytilus, gen. nov.

Nominiferous species [type-species]: *Melayumytilus smilacis*, sp. nov.

Referable to the Lepidosaphedini and to the Coccomytilina. The erection of this genus is rather tentative, and must be criticized by future detailed comparisons of coccomytilines. It differs from *Mitulaspis* mainly by having well-developed pore prominences and by the lateral tubercles sclerotized to spurs. By these characters and also by the widely separated L1s it may be distinguished from *Coccomytilus* so far as the latter is based on the figures of *C. convexus* presented by Ferris (1941). In *Melayumytilus smilacis* the spiracular disc pores are 5-locular in the 1st instar as well as in the 2nd instar and the adult female. The taxonomic significance of this character is uncertain because of our meagre and incomplete knowledge of disc pores in many other lepidosaphedines. *Melayumytilus* reminds me of *Acanthomytilus* owing to the widely separated L1s and their shape. Is it a mere coincidence that both these genera are associated with monocotyledons?

Metandaspis javanensis

Williams (1963: 30) [Java, on *Pterospermum javanicum*; provisionally referred to *Metandaspis*].

Material examined. Collected at Sepilok, Sandakan, Sabah, on *Pterospermum* sp. [Sterculiaceae], Nov. 13, 1988 [88ML-347]. Occurring on the undersurface of the leaf, burrowing under the upper epidermal layer.

Figures. 26 [adult female: pygidium], 33 [adult female: perivulvar disc pore], 34 [adult

female : anterior spiracular disc pore], 10 [1st instar larva], 49-53 [female tests].

Sclopetaspis danumensis, sp. nov.

Material examined. Collected at Danum Valley Conservation Area, Ulu Segama, Bahagian Tawau, Sabah, on *Ellipeia* sp. [Annonaceae], Oct. 23, 1988 [88ML-188]. Occurring on the undersurface of the leaf. Female test appearing like a small mass of fungal growth, being composed, externally, of abundant loose wax filaments; beneath the loose filaments the central body or core of the test is a hard mass, which is probably made of wax filaments agglutinated together by the anal substance; grayish brown, with wax filaments around the core white. Male test similar but smaller, without loose filaments on the posterior part of the core. Exuvial casts not recognized externally. Nominiferous specimen [holotype] : adult female.

Adult female (based on 30 specimens). Body fusiform, attaining about 1 mm in length and 0.5 mm in width; head narrowed anteriorly, metathorax and abd I-IV only gently produced laterally, pygidium rather narrow, little rounded along margin on each side. Derm membranous except for pygidium; reticulate on dorsal surface of pygidium around anus. Anus situated a little anteriorly to centre of pygidium. L1s situated in an apical recess of pygidium, divergent, with their apices widely separated from each other but their bases extending mesally and approaching to each other; coarsely serrate except on the extended mesal base. L2 with both lobules well represented and robust, coarsely serrate. Two or 3 low, broad, coarsely serrate processes at place of L3, and similar or conical processes at place of L4. A small conical process mesally of L2 and also of supposed L3 and L4; conical processes also occurring on prepygidial abdomen, but irregular. A small gland spine just laterally to L1, L2 and also supposed L3. Antennae set rather close together, each being a low tubercle with 2 setae. Anterior spiracle with 1-6 3-locular disc pores; posterior spiracle with none. Very small and short geminate-pore type ducts scattered on dorsal surface of prosoma in a narrow median area. Macroducts small, scattered submarginally and submedially on dorsal surface of pygidium and within margin on metathorax and abd I-IV; no differentiated marginal macroducts. Perivulvar disc pores in 5 groups, extra disc pores usually present on the preceding segment; 4-10 disc pores in median group, 9-17 in the anterolateral, and 5-13 in the posterolateral; extra disc pores 2-11, in a broad median region along the posterior margin of the segment, tending to form 3 groups corresponding to the median and anterolateral groups.

Second instar female (exuvial cast). Obovate, about 0.6 mm long and 0.4 mm wide. L1s separated from each other by a space much wider than one of them, conical, coarsely serrate. L2 separated from L1 by a space as wide as that between L1s, L2a similar to L1 but larger, L2b represented by a small conical process. L3 separated from L2 by a space much wider than that between L1 and L2. Geminate-pore type ducts scattered medially on dorsal surface of prosoma. Usual (2-barred) ducts very small and few; no marginal macroducts.

Second instar male. Marginal appendages more developed than in 2nd instar female, well represented on abd III-V, too. Antenna with 3 setae. Geminate-pore type ducts in 2 widely separated clusters on dorsal surface of prosoma, about 10-14 in each cluster. Anterior spiracle with 1 or 2 3-locular disc pores; posterior spira-

cle with none. Macroducts strewn submarginally. Microducts rather numerous on ventral surface.

Remarks. I compared this species with the figures of *Sclopetaspis laniger*, the nominifer of the genus, presented by Ferris (1937). It differs from the latter by the anus situated more posteriorly and by having much less numerous macroducts. But these species are very similar in the pygidial fringe not only in the adult female but also in the 2nd instar female, while these stages are, exceptionally to non-pupillarial Diaspidini, rather remarkably different from each other in the pygidial fringe. The tests of *S. danumensis* are characterized by having a hard core beneath abundant loose wax filaments. In *S. laniger*, too, 'beneath the woolly exterior the puparium [test] is hard and shell-like in texture' (Newstead, 1920). Above all, the production of tubular wax filaments, observed in *S. danumensis*, is quite extraordinary in the Diaspididae (see An examination of *Sclopetaspis*). If the wax filaments of *S. laniger* are also tubular, these 2 species should be congeneric beyond all doubt.

Figures. 11 [adult female], 27 [adult female: pygidium], 35 [adult female: perivulvar disc pore], 36 [adult female: anterior spiracular disc pore], 12 [2nd instar female], 13 [2nd instar male], 14 [1st instar larva], 54-63 [female test], 64-67 [male test].

ACKNOWLEDGEMENTS

In this paper some material collected in 1991 in Sarawak and Kedah is included. I take this opportunity to make my thanks to the Authorities concerned of the Government of Malaysia, the Government of Sarawak and the Government of Kedah for their approval for our surveys.

I take this opportunity to express my thanks to Dr Salleh bin Mohd Nor, Director of the Forest Research Institute of Malaysia, for his approval for our project and for the facilities he afforded us for materializing the surveys.

I am deeply grateful to Mr Abang Abdul Hamid, Entomologist, Forest Department of Sarawak, for his help and cooperation.

Mr K.M. Kochummen identified most of the host plants.

I am thankful to Dr Khoo Soo Ghee, University of Malaya, and to the staff members of the Entomology Division, Forest Research Institute of Malaysia, for their help in many ways.

Dr Tho Yow Pong, Coordinator for our project in Malaysia, passed away on December 13, 1991. By his cooperation and arrangements our surveys have been materialized successfully for these years. I deeply regret his sudden demise, and I express my heartfelt thanks to him for his great help.

LITERATURE

- Balachowsky, A.S. 1954. Les Cochenilles Paléarctiques de la Tribu des Diaspidini. Institut Pasteur, 450 pp.
- Borchsenius, N.S. 1965. Essay on the classification of the armored scale insects (Homoptera, Coccoidea, Diaspididae). Revue d'Entomologie de l'URSS 44: 362-376 [in Russian].
- Borchsenius, N.S. 1966. A Catalogue of the Armoured Scale Insects (Diaspidioidea) of the World. Nauka, Moscow and Leningrad, 450 pp.
- Comstock, J.H. 1883. Second report on scale insects. Cornell University Agricultural

- Experiment Station, Department of Entomology, Report 2:47-143, pls. I-IV (reprinted in Cornell Univ. Agr. Expt. Sta. Bul. 372, 1916).
- Eldredge, N. and Stanley, S.M. (eds.). 1984. Living Fossils. Springer-Verlag, xi+291 pp.
- Ferris, G.F. 1936. Contributions to the knowledge of the Coccoidea (Homoptera) II. Microentomology 1: 17-92.
- Ferris, G.F. 1937. Contributions to the knowledge of the Coccoidea (Homoptera) VI. Microentomology 2: 103-122.
- Ferris, G.F. 1941. Contributions to the knowledge of the Coccoidea (Homoptera) X. Microentomology 6: 11-24.
- Ghauri, M.S.K. 1962. The morphology and taxonomy of male scale insects (Homoptera : Coccoidea). British Museum (Natural History), vii+221 pp.
- Gould, S.J. 1991. The disparity of the Burgess Shale arthropod fauna and the limits of cladistic analysis: Why we must strive to quantify morphospace. Paleobiology 17: 411-423.
- Hall, W.J. 1946. On the Ethiopian Diaspidini (Coccoidea). Transactions of the Royal Entomological Society of London 97(20): 497-583.
- Hall, W.J. and Williams, D.J. 1962. New Diaspididae (Homoptera : Coccoidea) from the Indo-Malayan Region. Bulletin of the British Museum (Natural History), Entomology 12(2), 43 pp.
- Howell, J.O. and Tippins, H.H. 1976. Descriptions of first instars of nominal type-species of eight diaspidid tribes. Annals of the Entomological Society of America 70: 119-135.
- Howell, J.O. and Tippins, H.H. 1990. The immature stages. In: Rosen, D. (ed.), Armored Scale Insects, their Biology, Natural Enemies and Control [World Crop Pest 4A], Elsevier, pp. 29-42.
- Kozár, F. 1990. Zoogeographical considerations. In: Rosen, D. (ed.), Armored Scale Insects, their Biology, Natural Enemies and Control [World Crop Pest 4A], Elsevier, pp. 135-148.
- Lindinger, L. 1932. Beiträge zur Kenntnis der Schildläuse. Konowia 11: 177-205.
- McGillivray, A.D. 1921. The Coccidae. Scarab Company, Urbana, 502 pp.
- Munting, J. 1970. On some new genera and species of armoured scale insects (Homoptera : Diaspididae) from southern Africa. Novos Taxa Entomologici 84: 3-14.
- Newstead, R. 1913. Notes on scale-insects (Coccidae). Part II. Bulletin of Entomological Research 4: 301-311.
- Newstead, R. 1920. Observations on scale-insects (Coccidae).-VI. Bulletin of Entomological Research 10: 175-207, pl. XVI.
- Takagi, S. 1990a. SEM observations on the tests of some Diaspididae (Homoptera : Coccoidea). Insecta Matsumurana New Series 44: 17-80.
- Takagi, S. 1990b. Disc pores of Diaspididae: Microstructure and taxonomic value (Homoptera : Coccoidea). Insecta Matsumurana New Series 44: 81-112.
- Takagi, S. 1992. A contribution to conchaspidid systematics. Insecta Matsumurana New Series 46: 1-71.
- Takagi, S. Tho Y.P. and Khoo S.G. 1988. Does *Africaspis* (Homoptera : Coccoidea : Diaspididae) occur in Asia? Insecta Matsumurana New Series 39: 1-34.
- Williams, D.J. 1960. Some new Diaspidini (Coccoidea : Homoptera) from Africa. Bulletin of the British Museum (Natural History), Entomology 9(8), 29 pp.
- Williams, D.J. 1963. Synoptic revisions of I. *Lindingaspis* and II. *Andaspis* with two new allied genera (Homoptera : Coccoidea). Bulletin of the British Museum (Natural History), Entomology 15(1), 31 pp.
- Williams, D.J. and Watson, G.W. 1988. The Scale Insects of the Tropical South Pacific Region. Part 1. The Armoured Scales (Diaspididae). C.A.B. International Institute of Entomology, 289 pp.

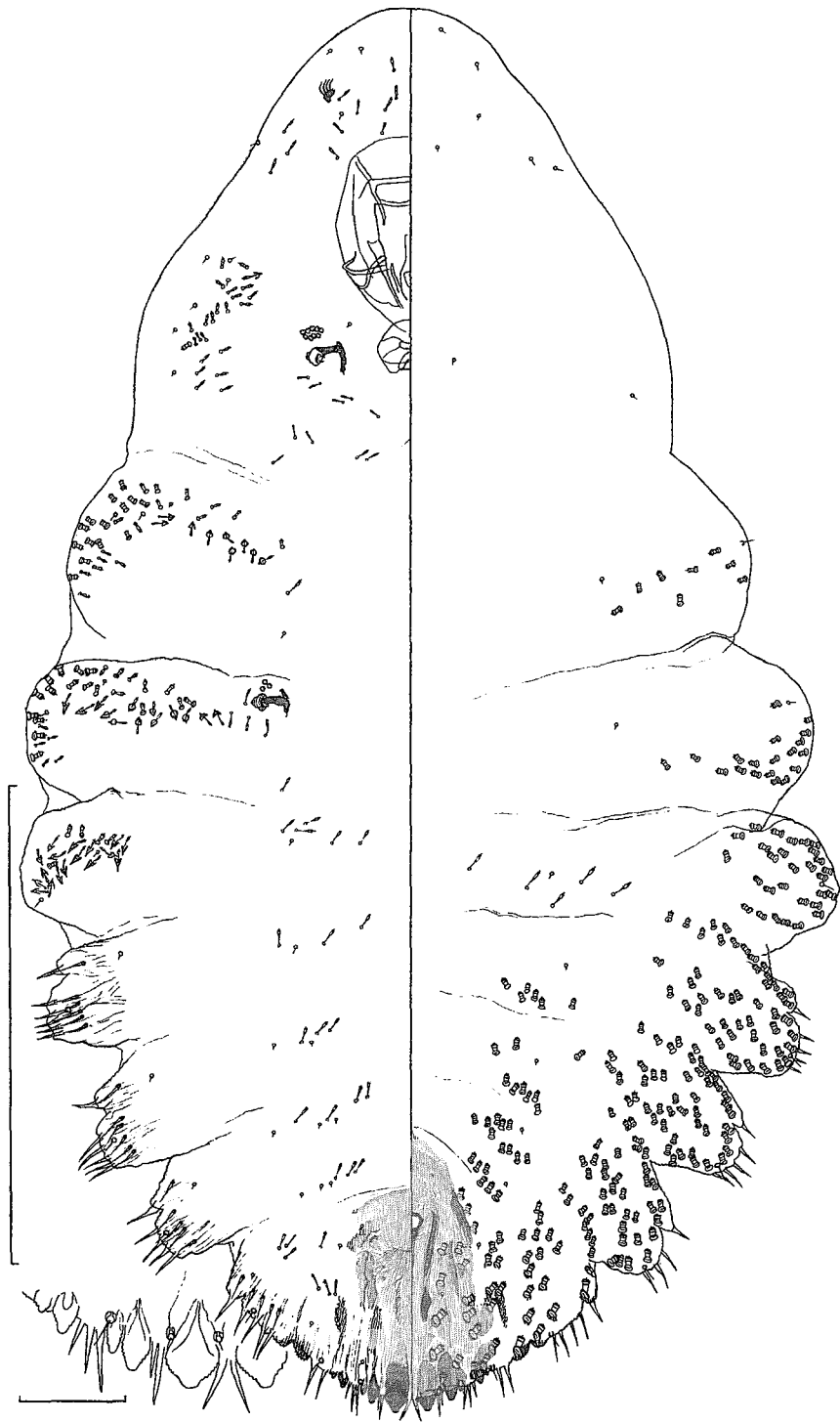


Fig. 1. *Mitulaspis funtumiae*, adult female. Scale: 0.5 mm for body; 0.05 mm for pygidial margin.

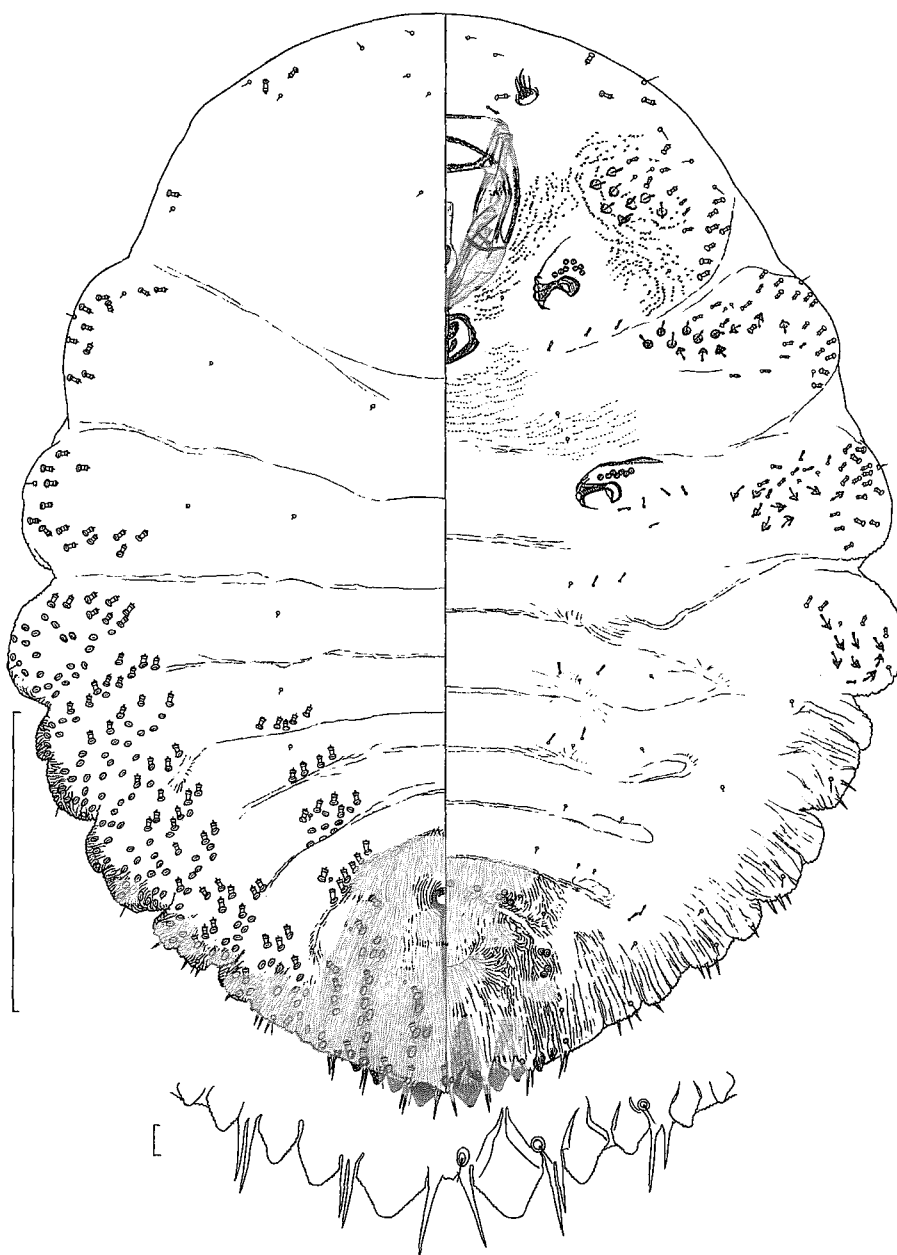


Fig. 2. *Mitulaspis malayana*, adult female [90ML-21]. Scale : 0.5 mm for body ; 0.01 mm for pygidial margin.



Fig. 3. *Mitulaspis malayana*, 2nd instar male [90ML-21]. Scale: 0.1 mm.

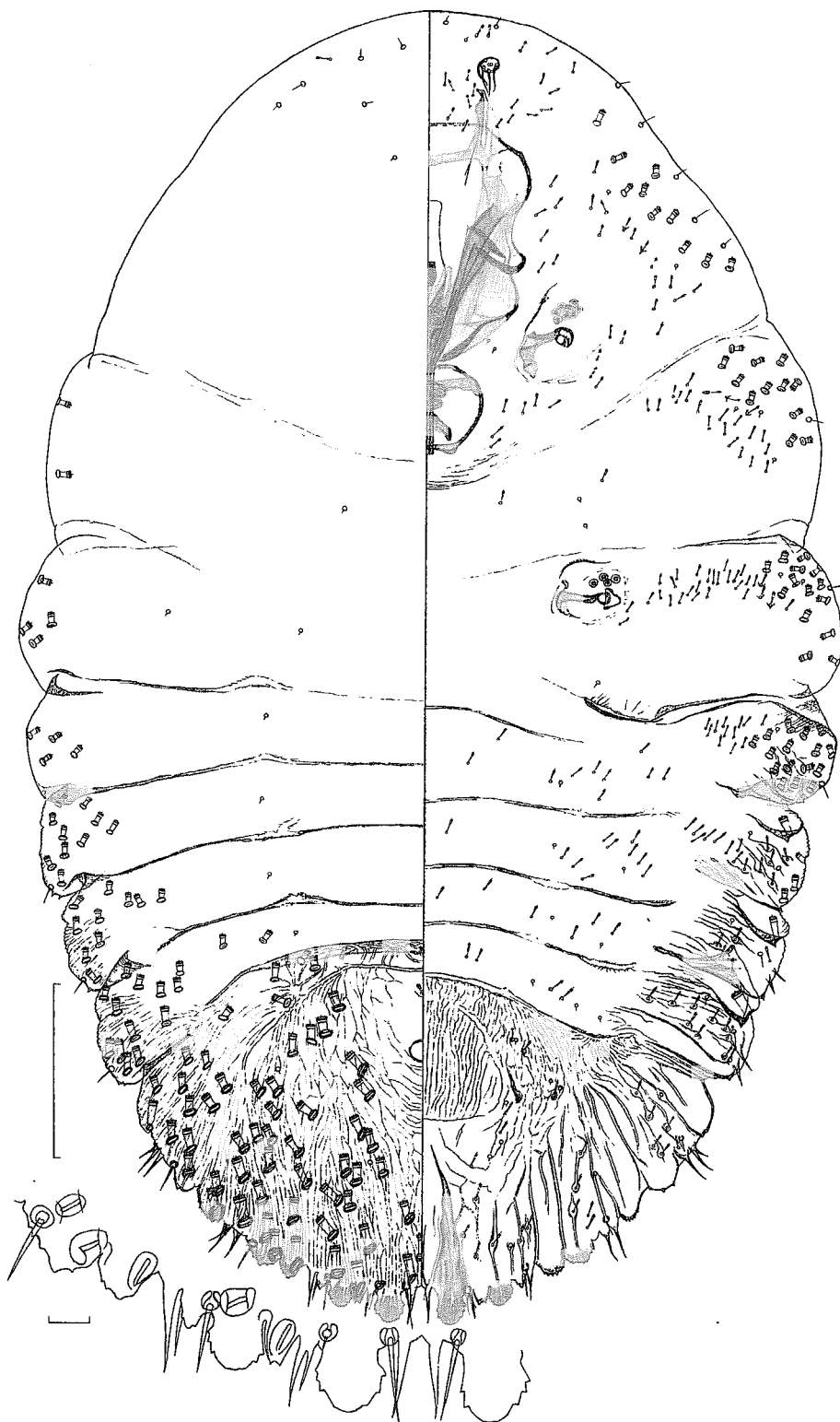


Fig. 4. *Melayumytilus smilacis*, adult female, figured from a teneral specimen [86ML-378].
Scale: 0.1 mm for body ; 0.01 mm for pygidial margin.

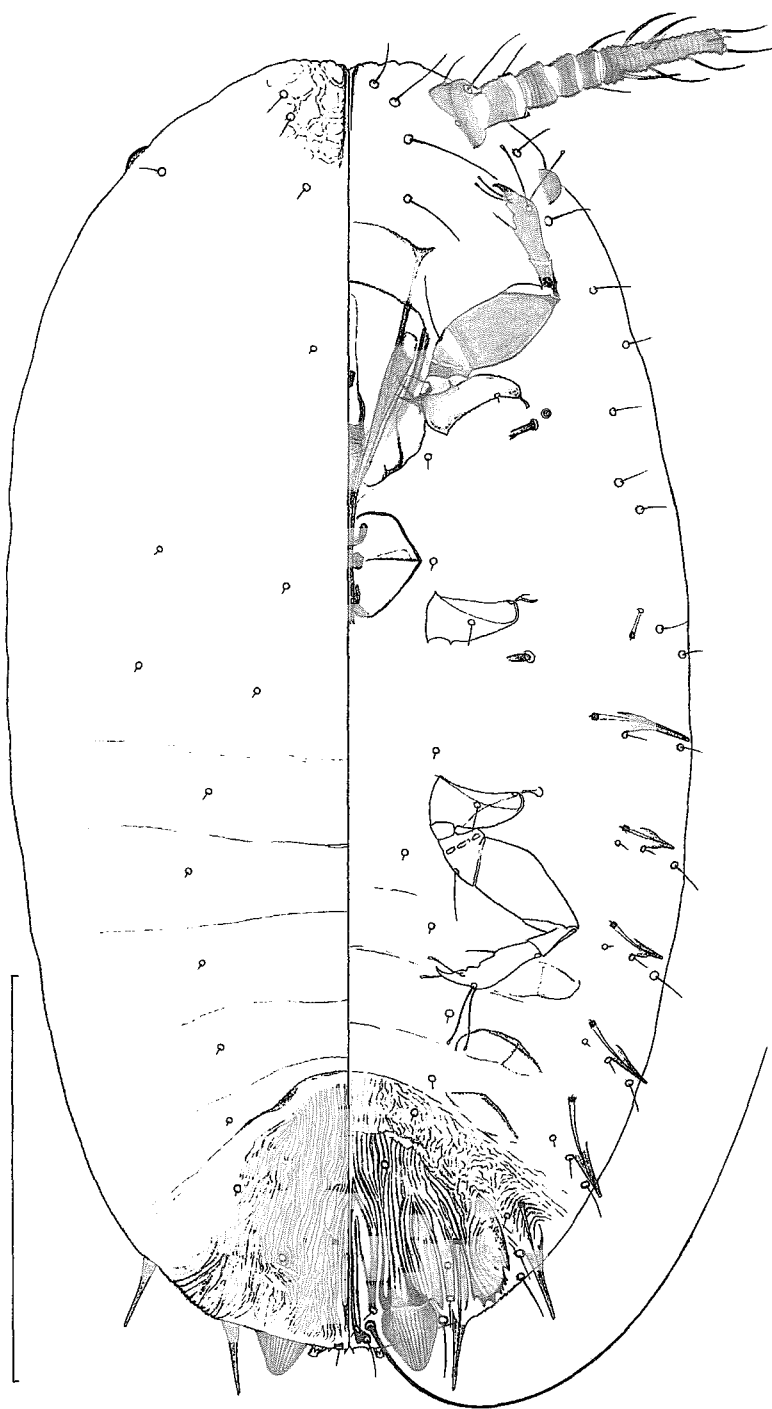


Fig. 5. *Mitulaspis malayana*, 1st instar larva [90ML-21]. Scale : 0.1 mm.

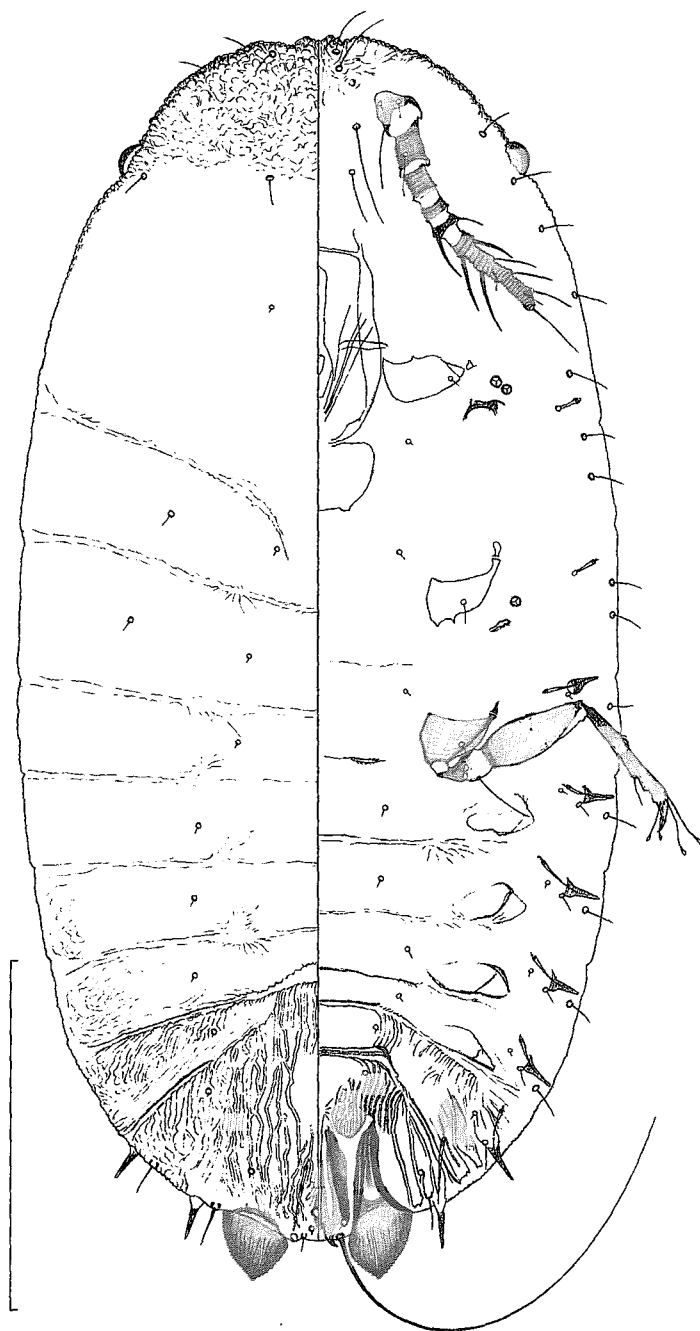


Fig. 6. *Howardia biclavis*, 1st instar larva [90ML-71]. Scale: 0.1 mm.

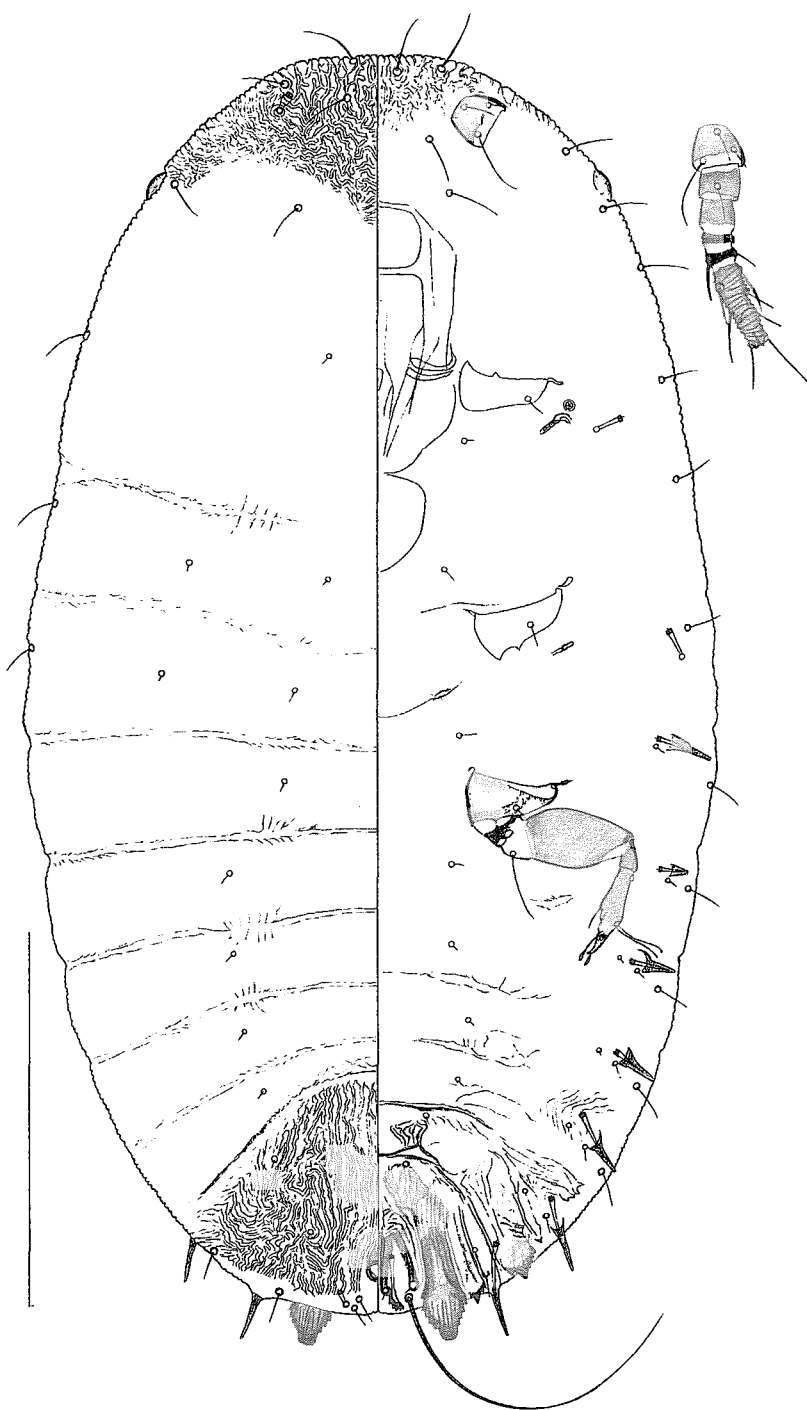


Fig. 7. *Melayumytilus smilacis*, 1st instar larva [90ML-269]. Scale: 0.1 mm.

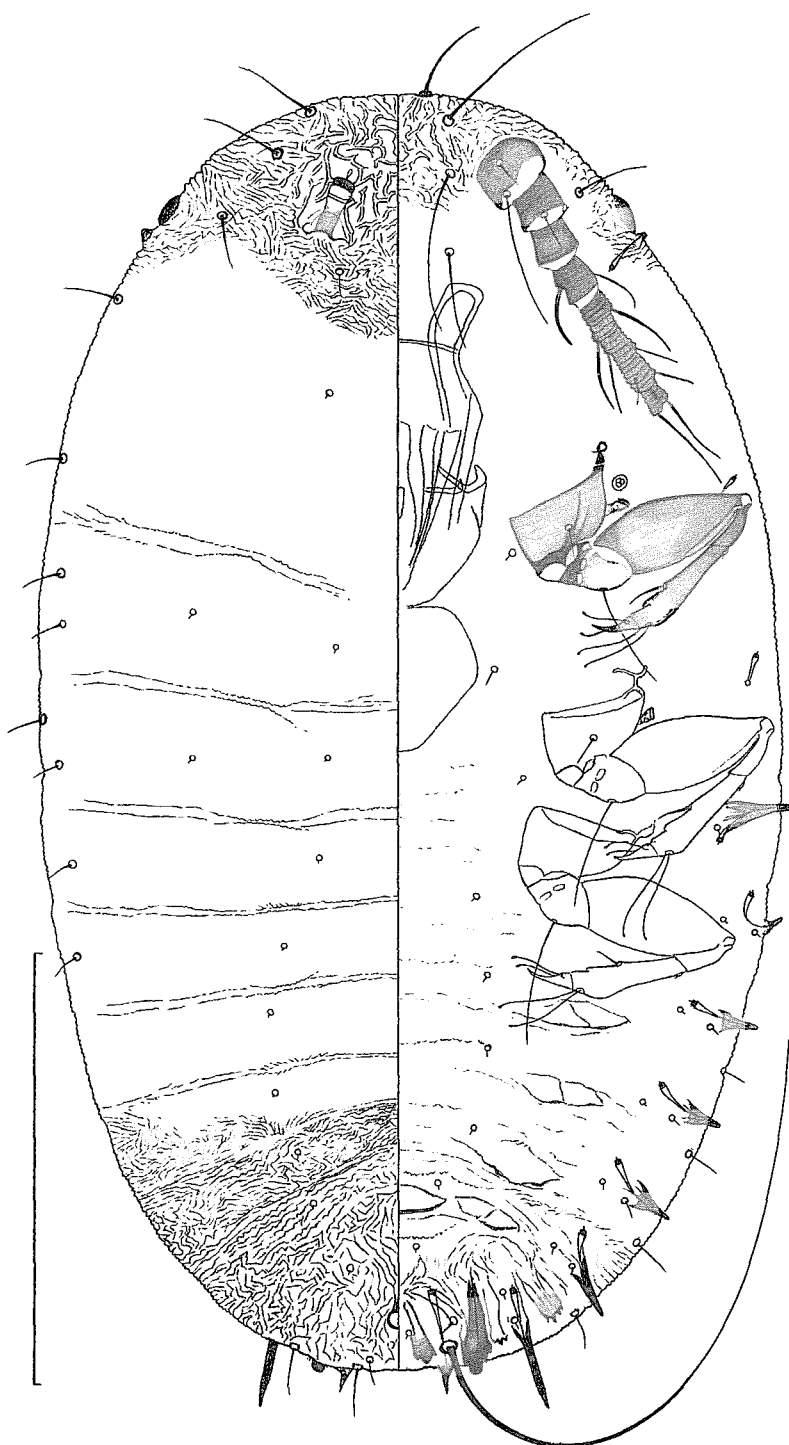


Fig. 8. *Aonidomytilus albus*, 1st instar larva [Thailand, on cassava]. Scale : 0.1 mm.

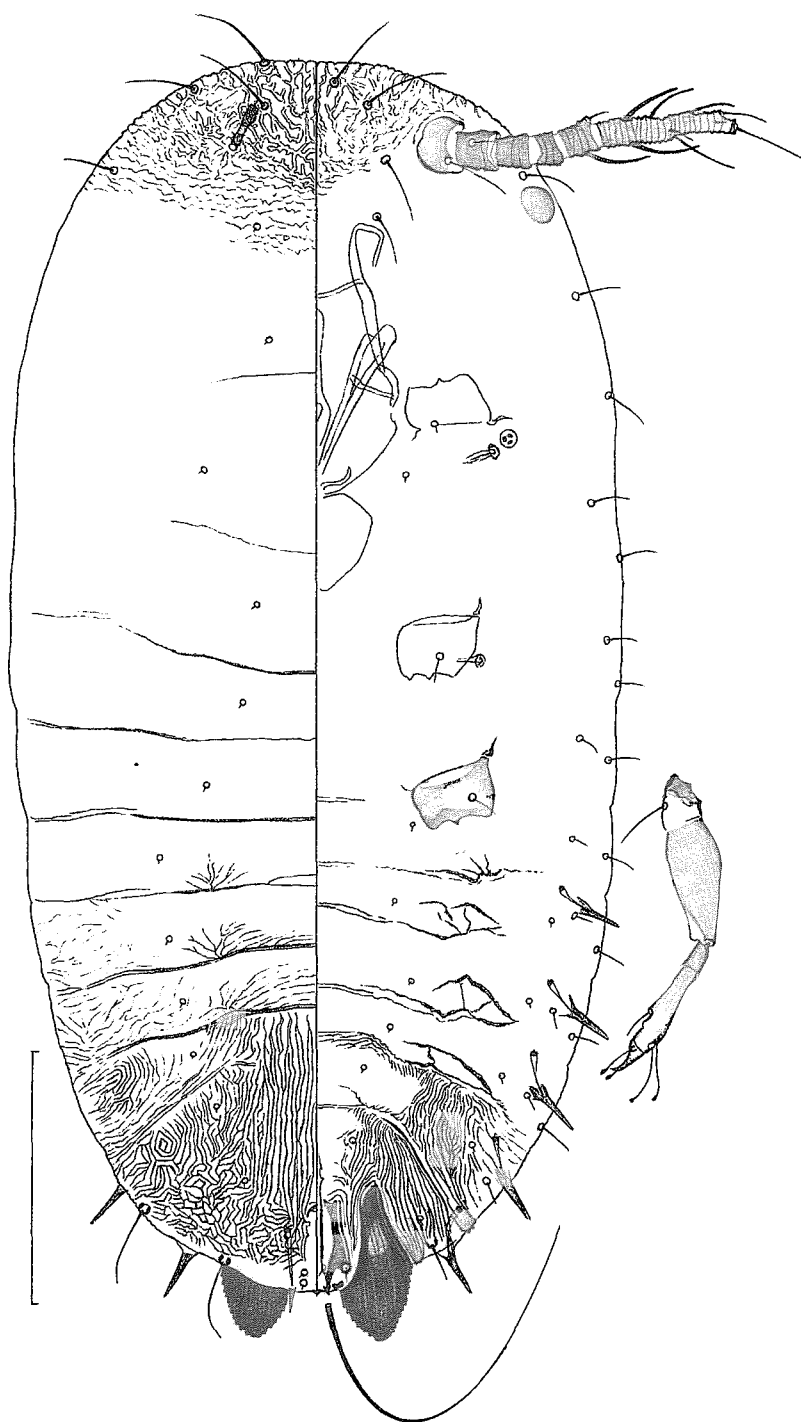


Fig. 9. *Andaspis crawii*, 1st instar larva [Tusima Is., Japan, on *Castanopsis cuspidata*].
Scale: 0.05 mm.

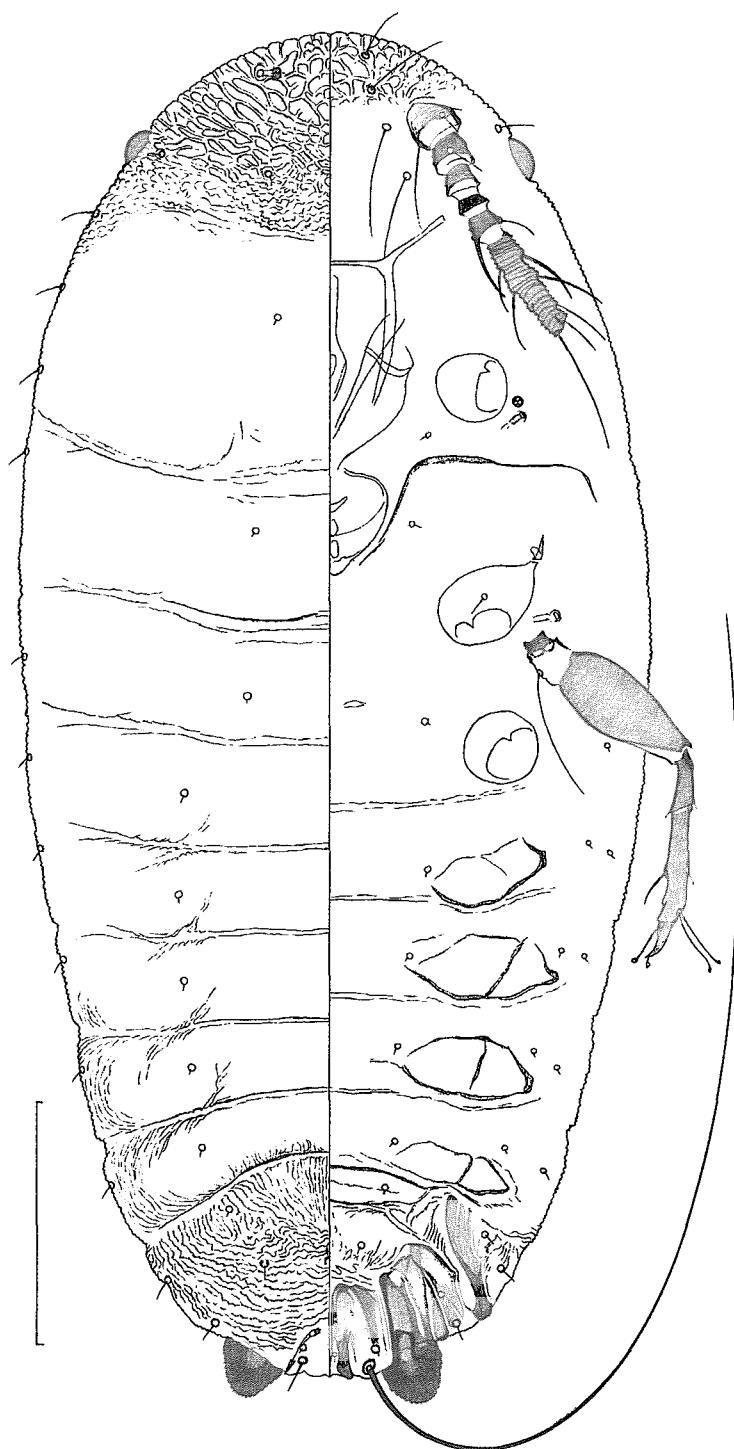


Fig. 10. *Metandaspis javanensis*, 1st instar larva. Scale: 0.05 mm.



Fig. 11. *Sclopetaspis danumensis*, adult female. Scale: 0.1 mm for body; 0.01 mm for pygidial margin.

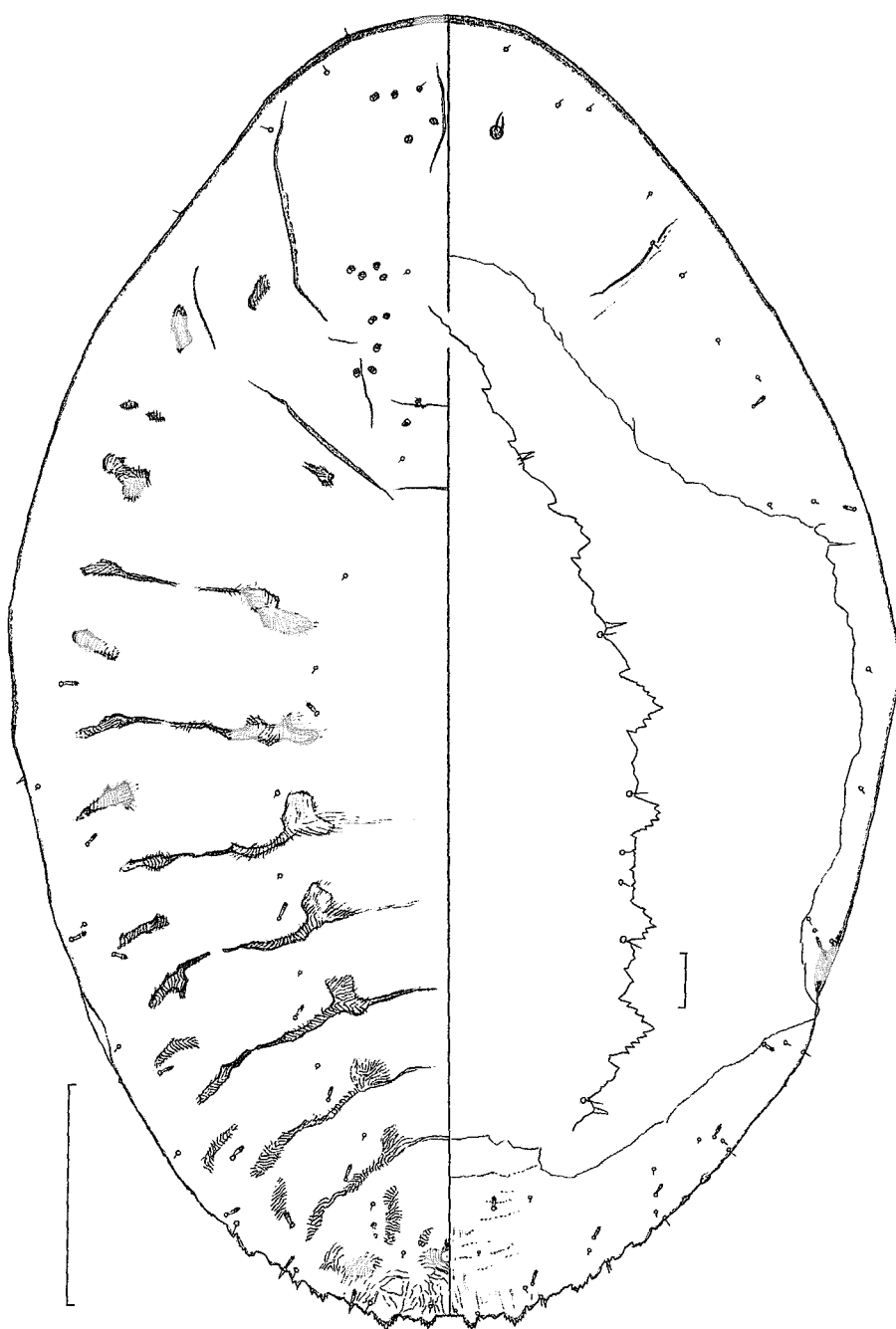


Fig.12. *Sclopetaspis danumensis*, 2nd instar female, exuvial cast. Scale: 0.1 mm for body; 0.01 mm for pygidial margin.

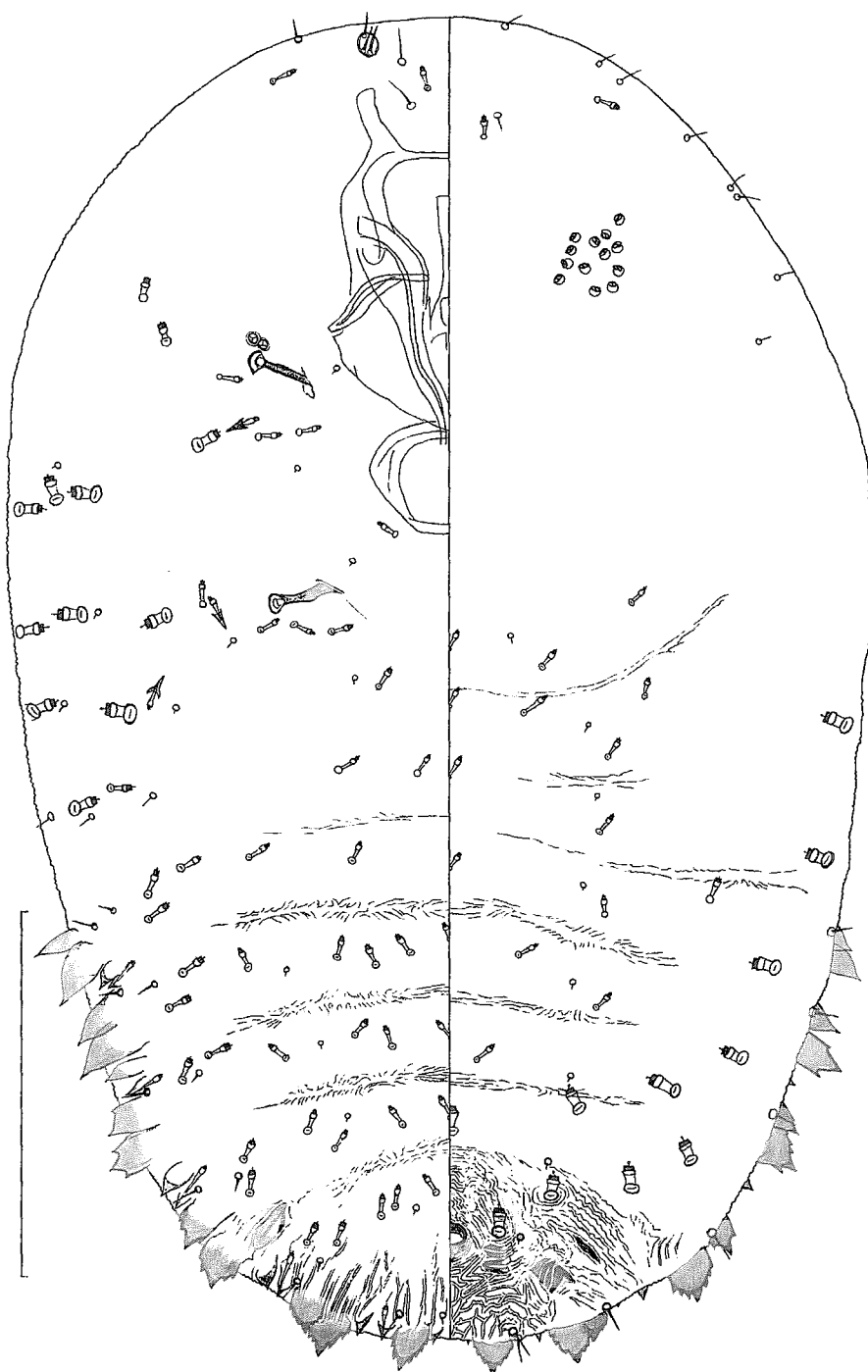


Fig. 13. *Sclopetaspis danumensis*, 2nd instar male. Scale: 0.1 mm.

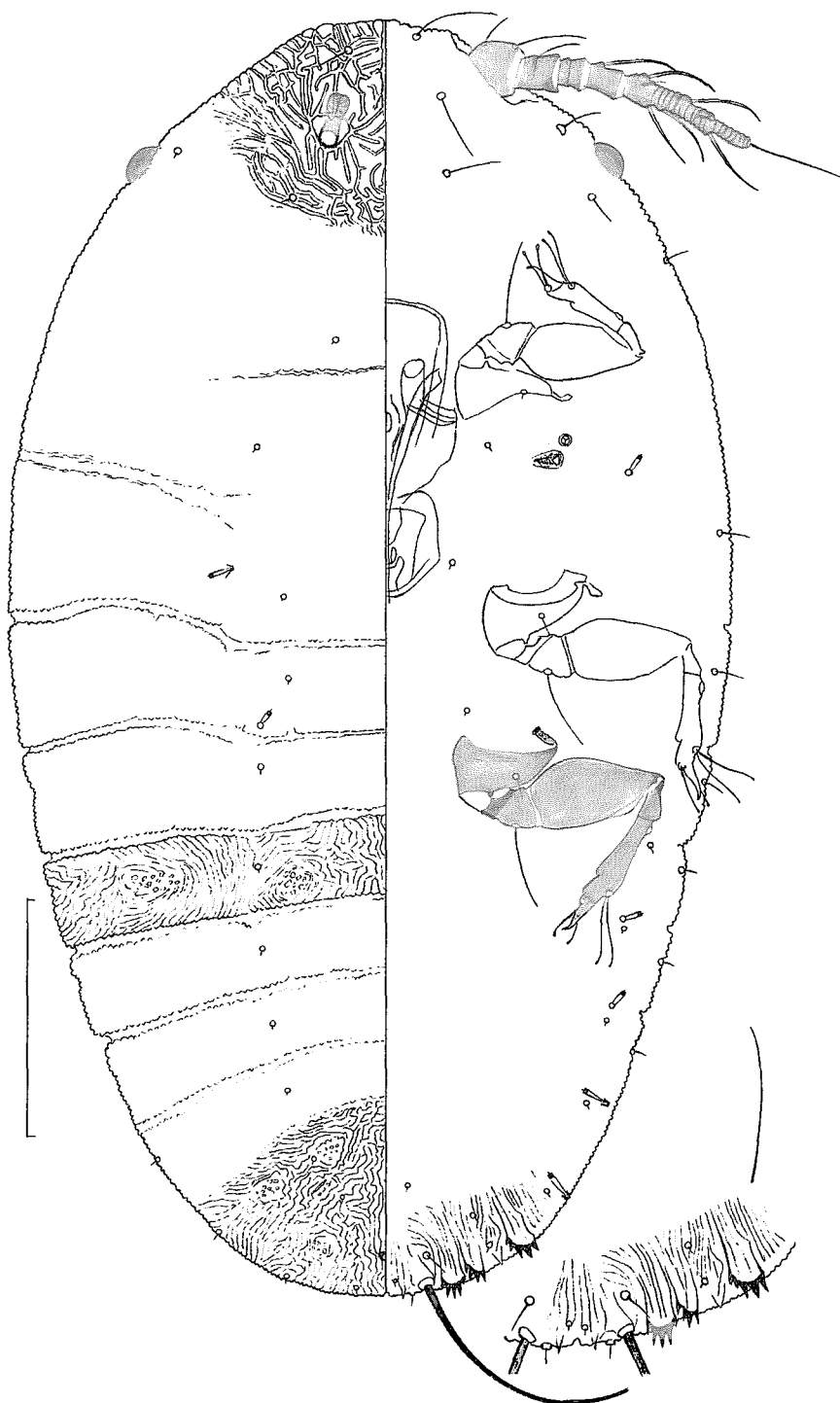


Fig. 14. *Sclopetaspis danumensis*, 1st instar larva. Scale: 0.05 mm (for body).

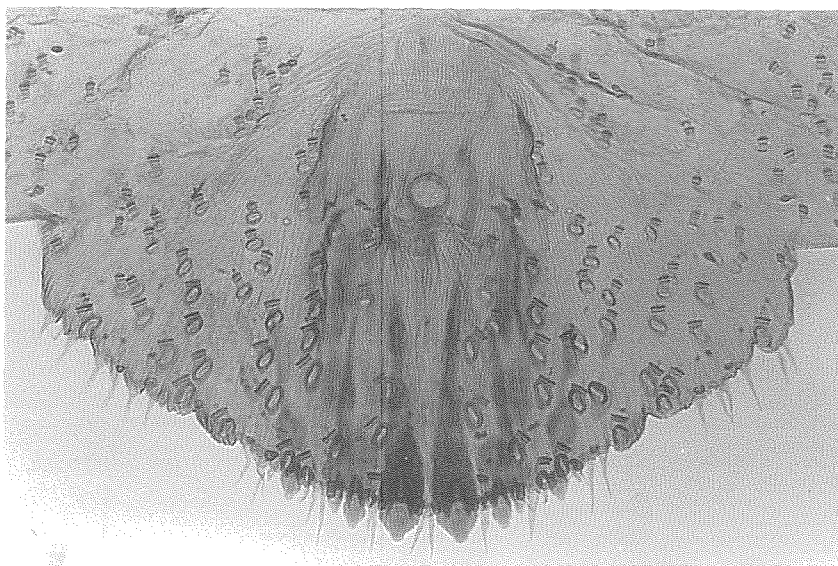


Fig. 15. *Mitulaspis funtumiae*, adult female, pygidium.

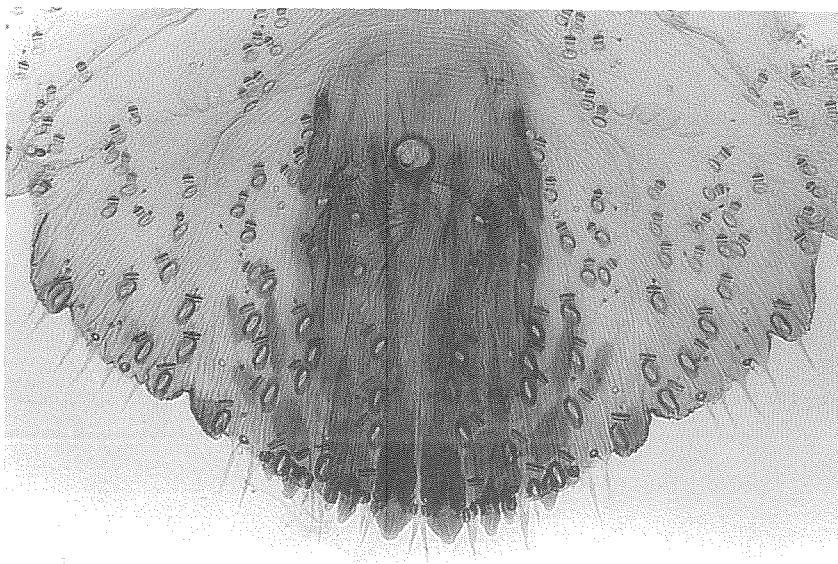


Fig. 16. *Mitulaspis funtumiae*, adult female, pygidium.

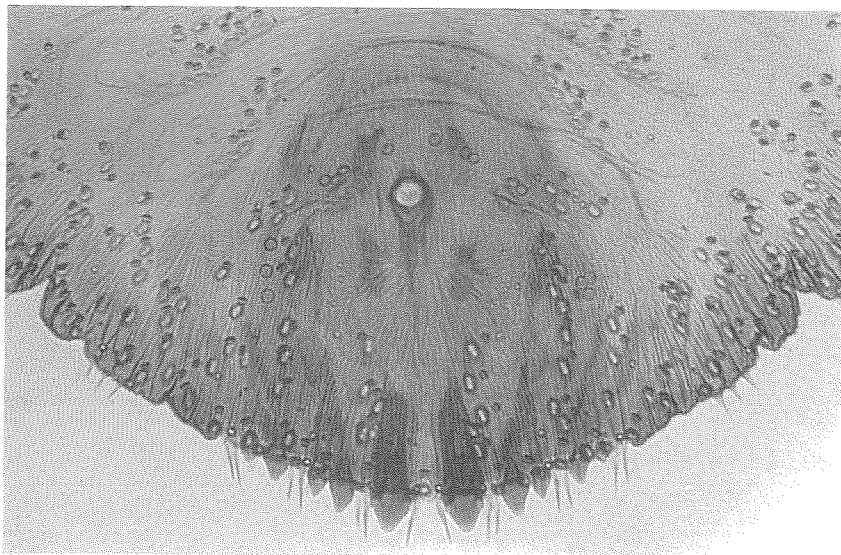


Fig. 17. *Mitulaspis malayana*, adult female : pygidium [90ML-21].

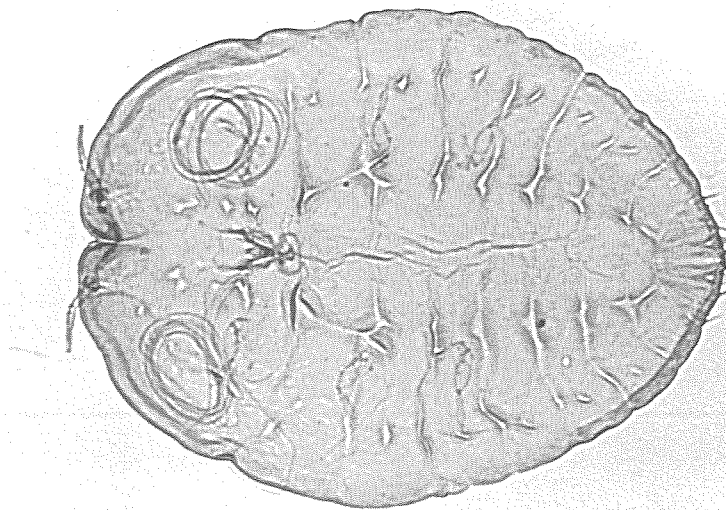


Fig. 18. *Mitulaspis malayana*, 1st instar larva, full- grown [90ML-21]. Note that the head is incised medially.

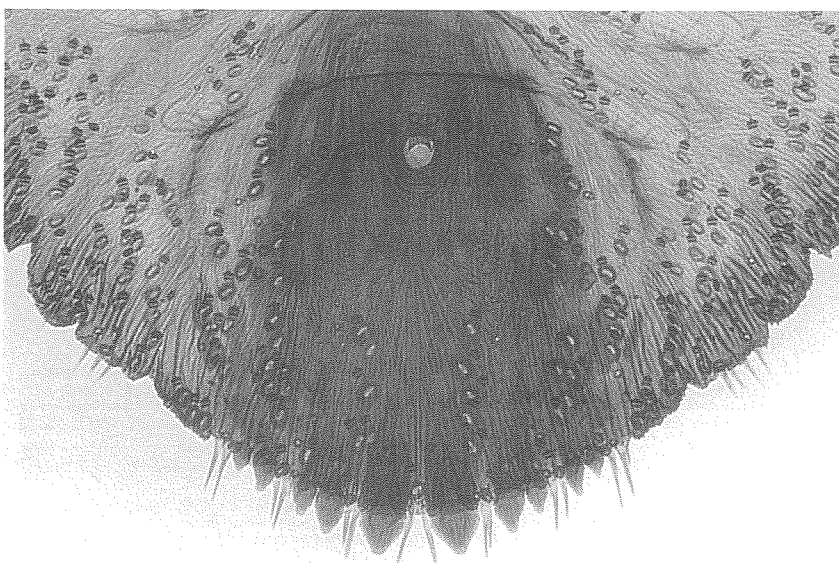


Fig. 19. *Mitulaspis malayana*, adult female: pygidium [91ML-170].

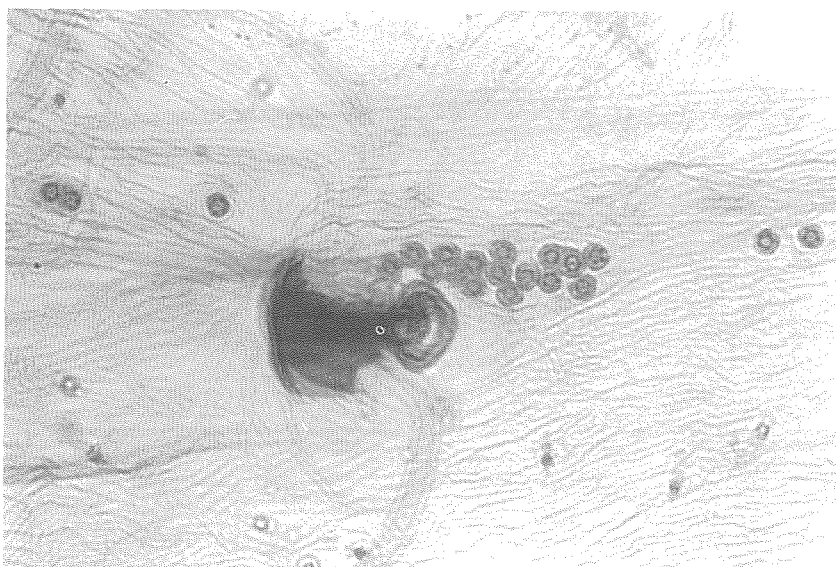


Fig. 20. *Mitulaspis malayana*, adult female: posterior spiracle [91ML-170]. Note the occurrence of extra disc pores.

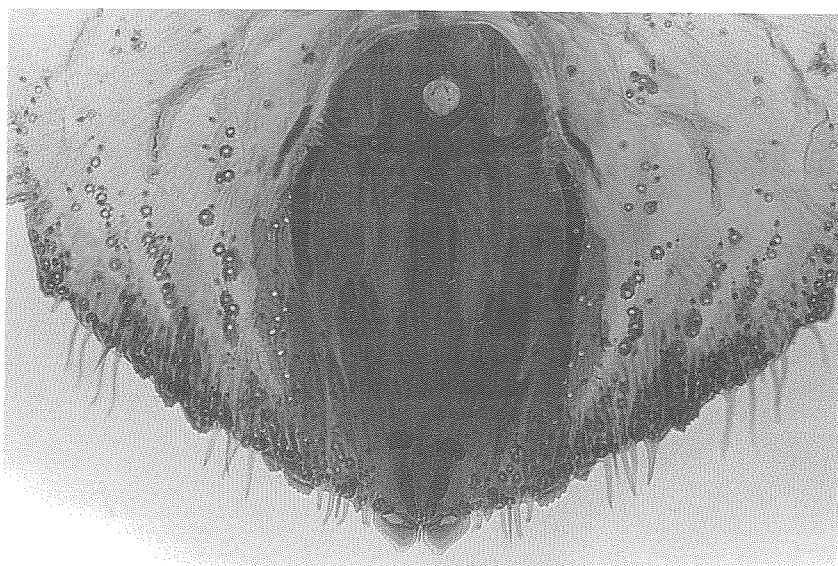


Fig. 21. *Howardia biclavis*, adult female : pygidium [90ML-71].

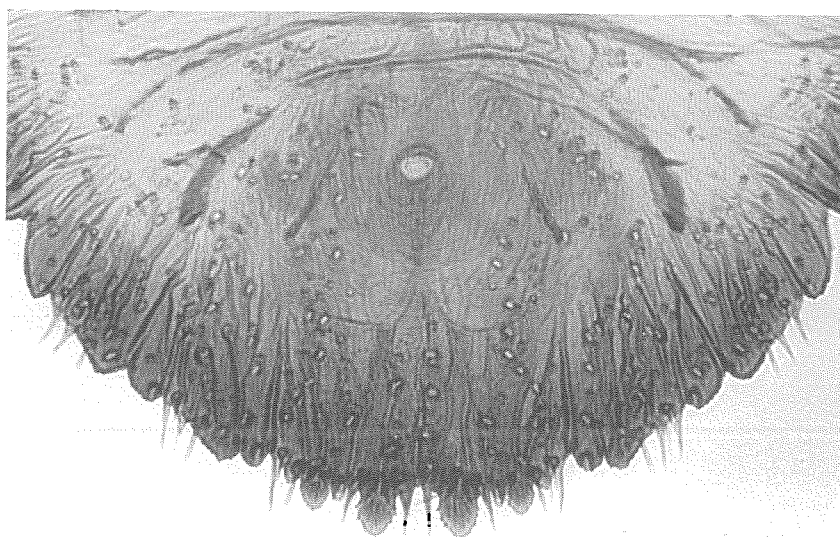


Fig. 22. *Melayumytilus smilacis*, adult female : pygidium [90ML-269].

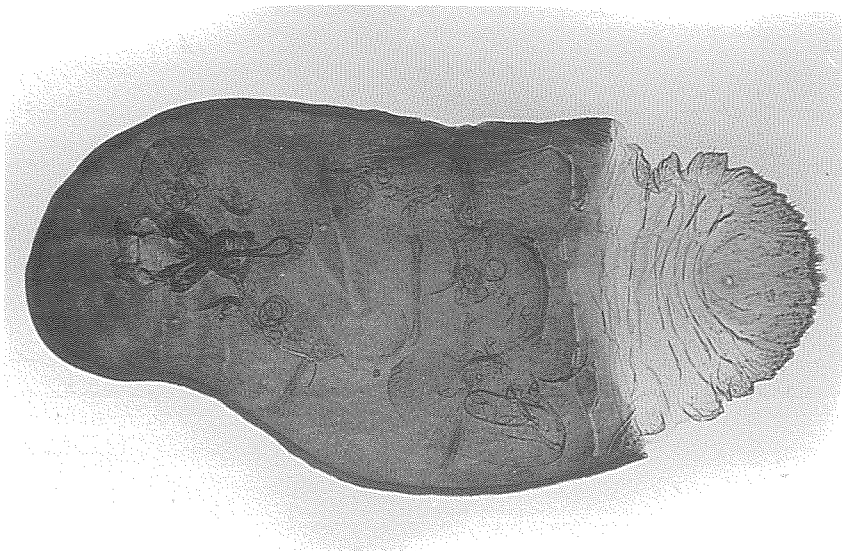


Fig. 23. *Melayumytilus smilacis*, adult female, a full-grown specimen [86ML-378].

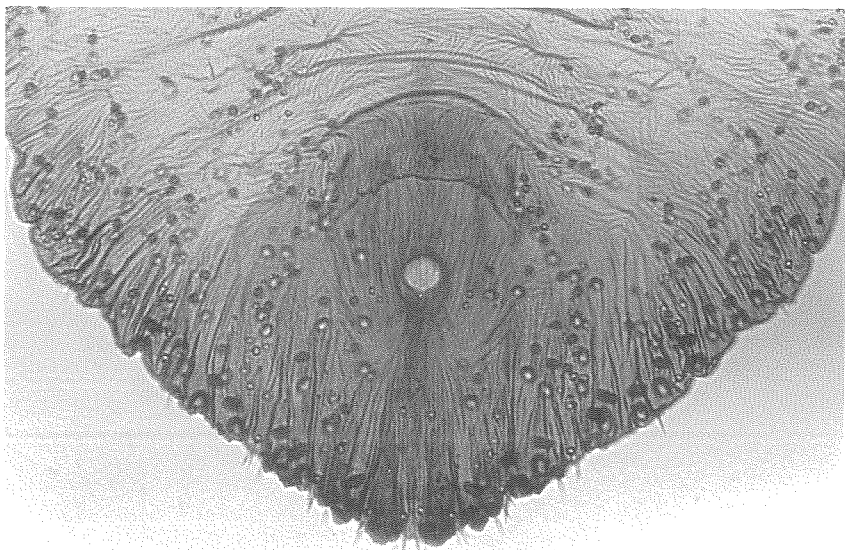


Fig. 24. *Aonidomytilus albus*, adult female: pygidium [Thailand, on cassava].

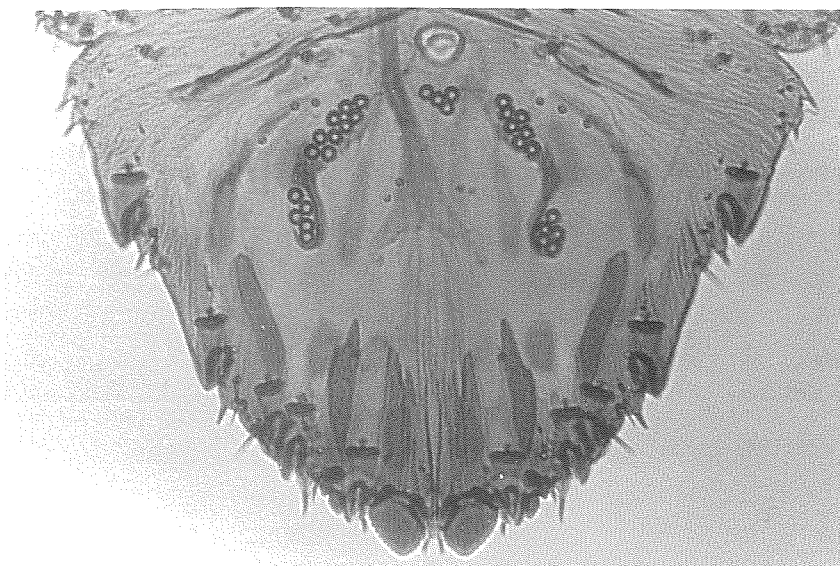


Fig. 25. *Andaspis crawii*, adult female: pygidium [Tokuno-sima, Japan, on *Castanopsis cuspidata*].

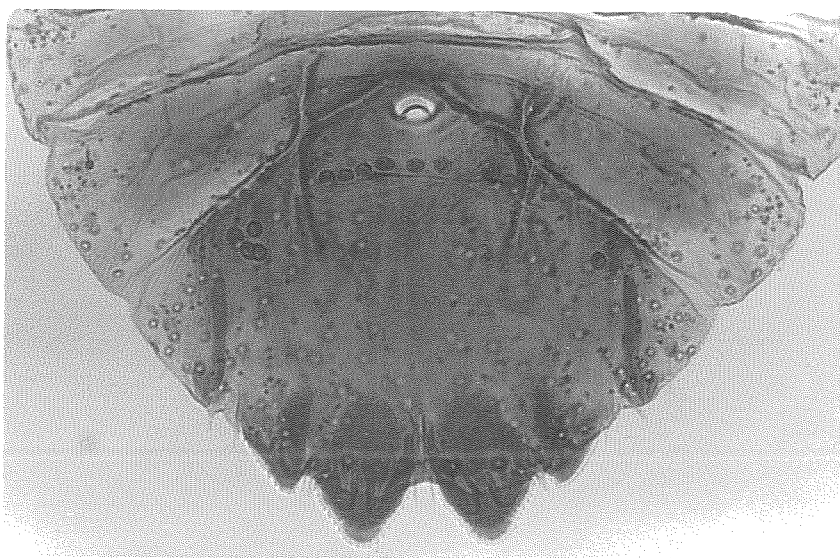


Fig. 26. *Metandaspis javanensis*, adult female: pygidium.

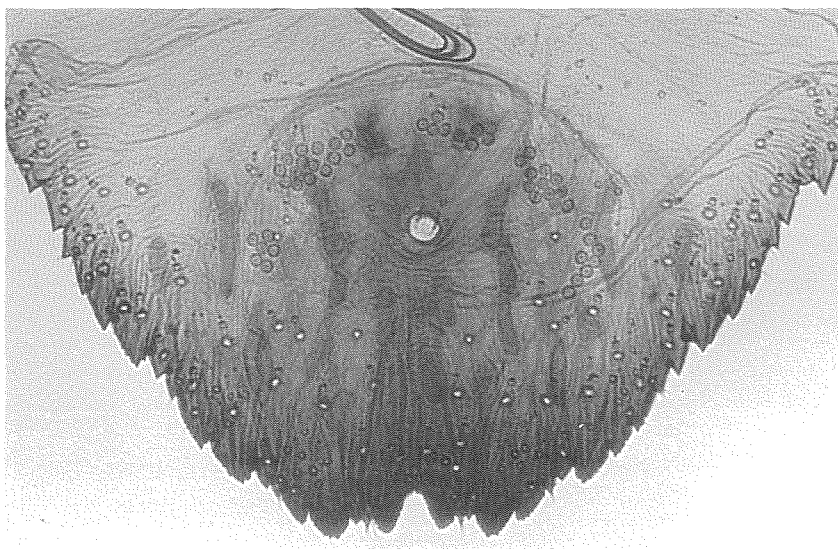


Fig. 27. *Scolopetaspis danumensis*, adult female: pygidium.

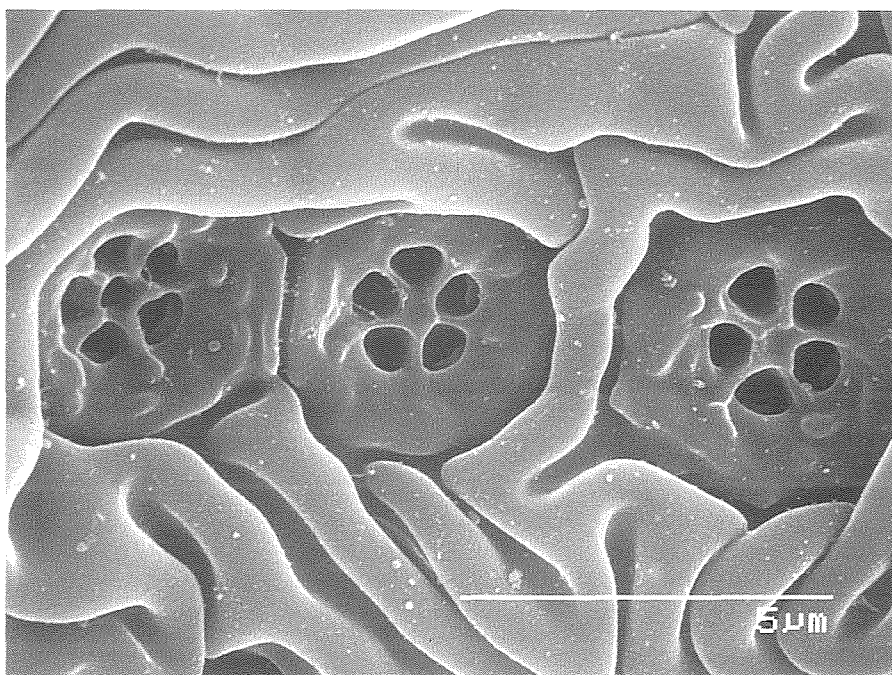


Fig. 28. *Mitulaspis malayana*, adult female: perivulvar disc pores [90ML-21].

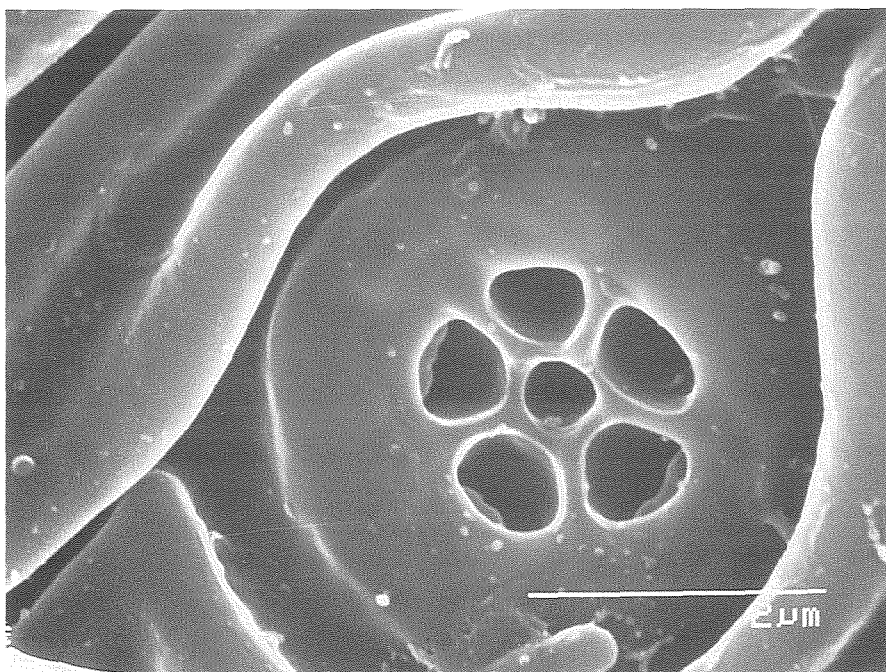


Fig. 29. *Mitulaspis malayana*, adult female : perivulvar disc pore [90ML-21].

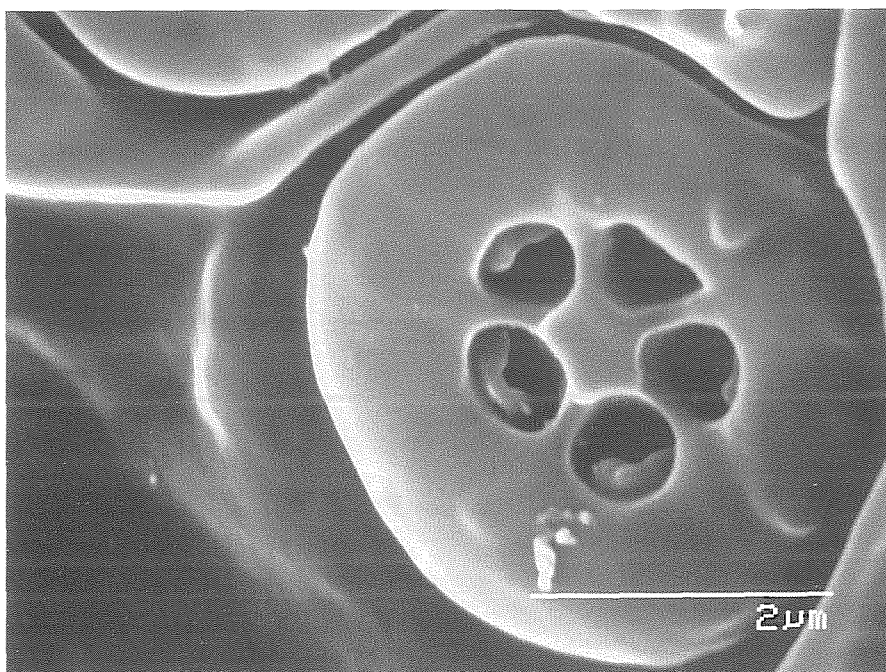


Fig. 30. *Mitulaspis malayana*, adult female : spiracular disc pore [90ML-21].

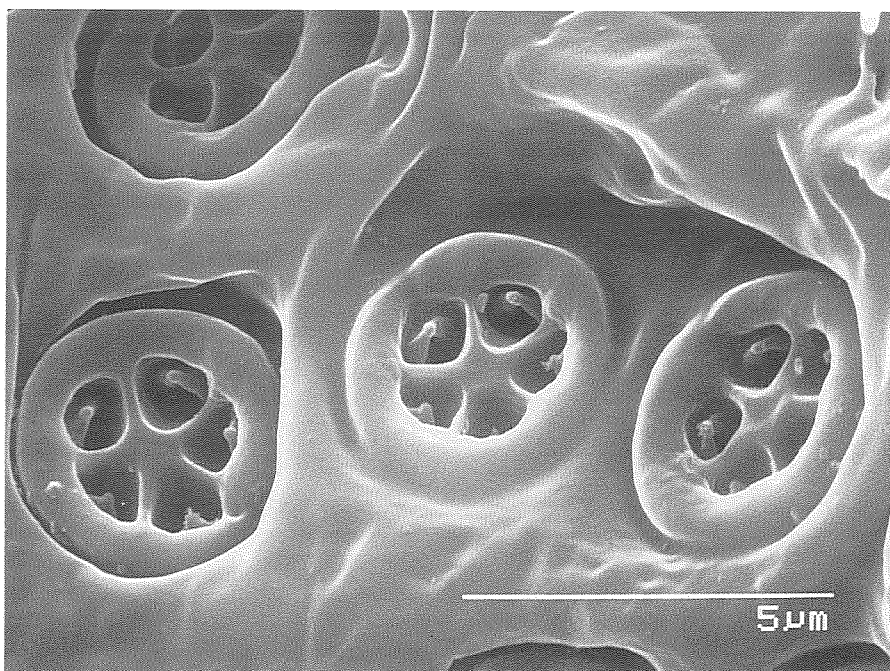


Fig. 31. *Howardia biclavis*, adult female : anterior spiracular disc pores [88ML-289].

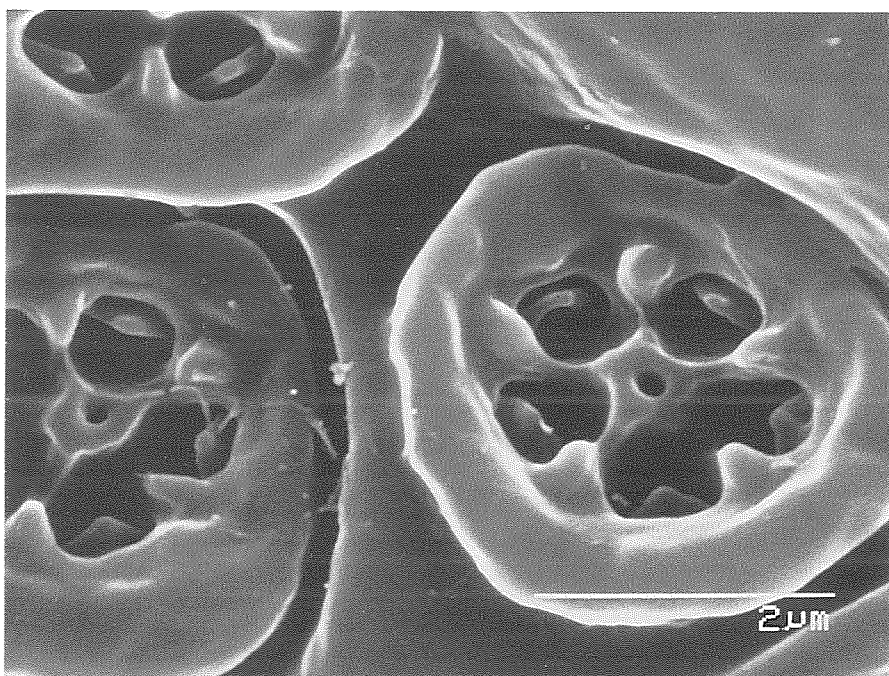


Fig. 32. *Melayumytilus smilacis*, adult female : posterior spiracular disc pore [86ML-378].

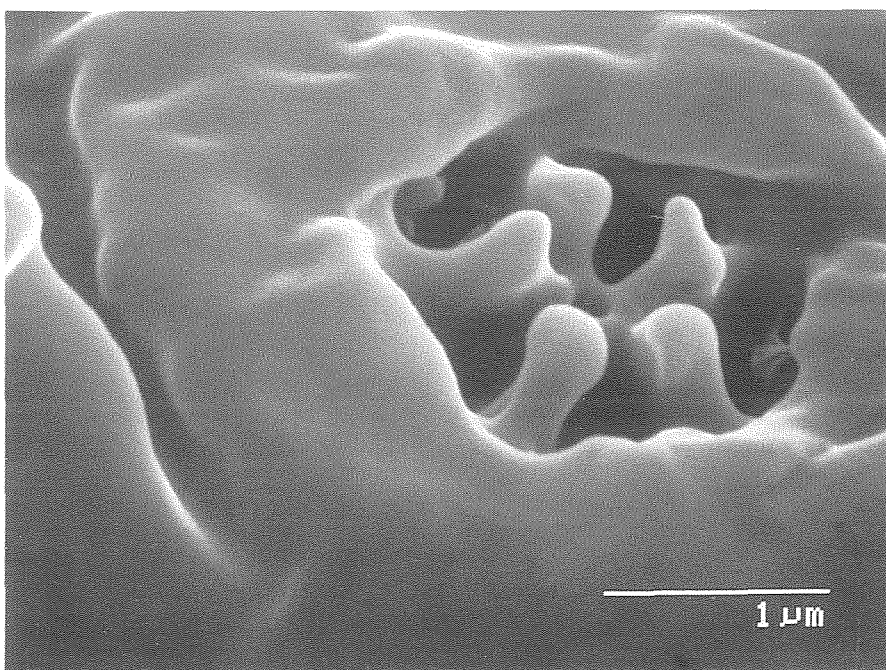


Fig. 33. *Metandaspis javanensis*, adult female : perivulvar disc pore.

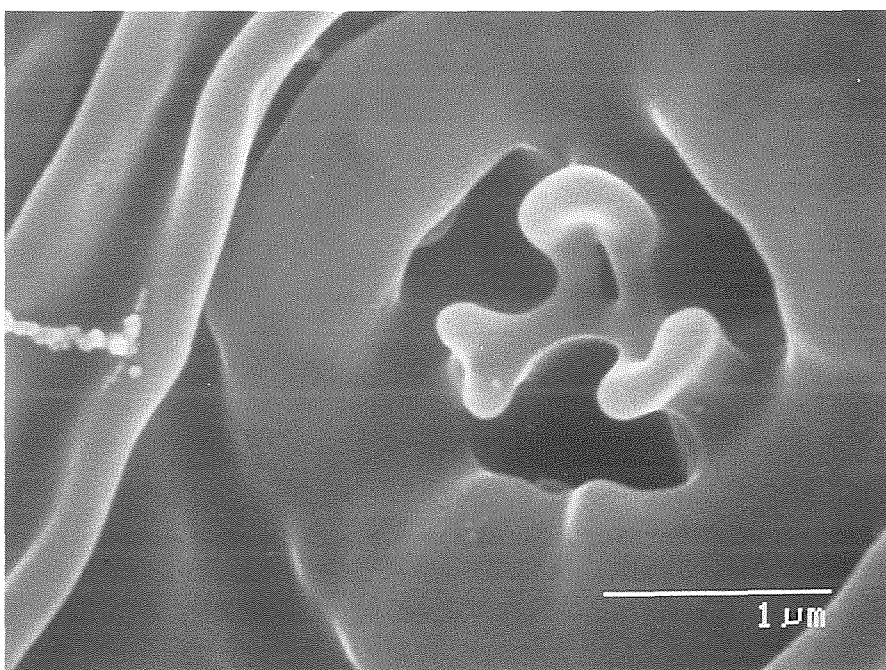


Fig. 34. *Metandaspis javanensis*, adult female : anterior spiracular disc pore.

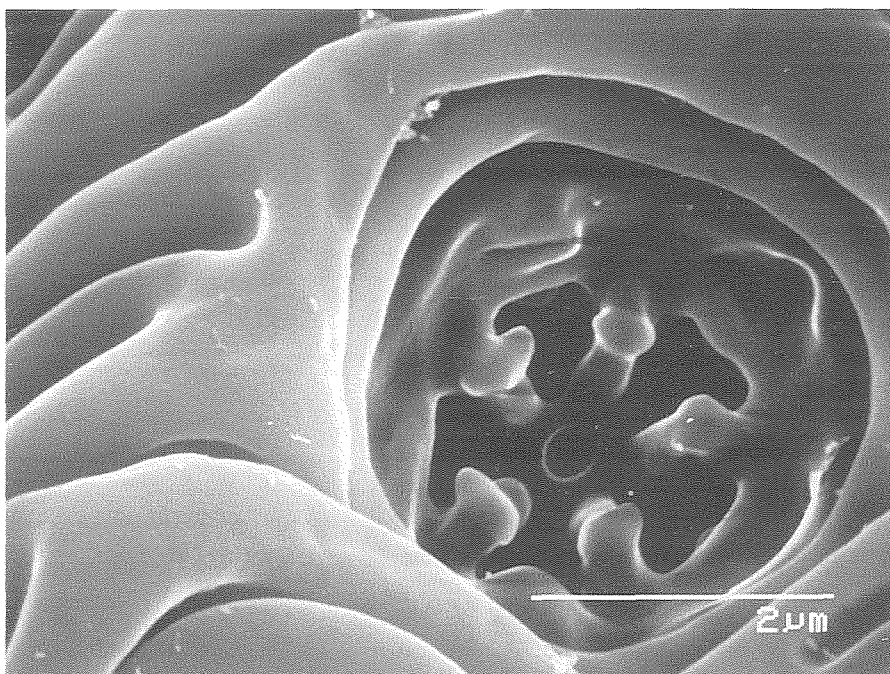


Fig. 35. *Sclopetaspis danumensis*, adult female : perivulvar disc pore.

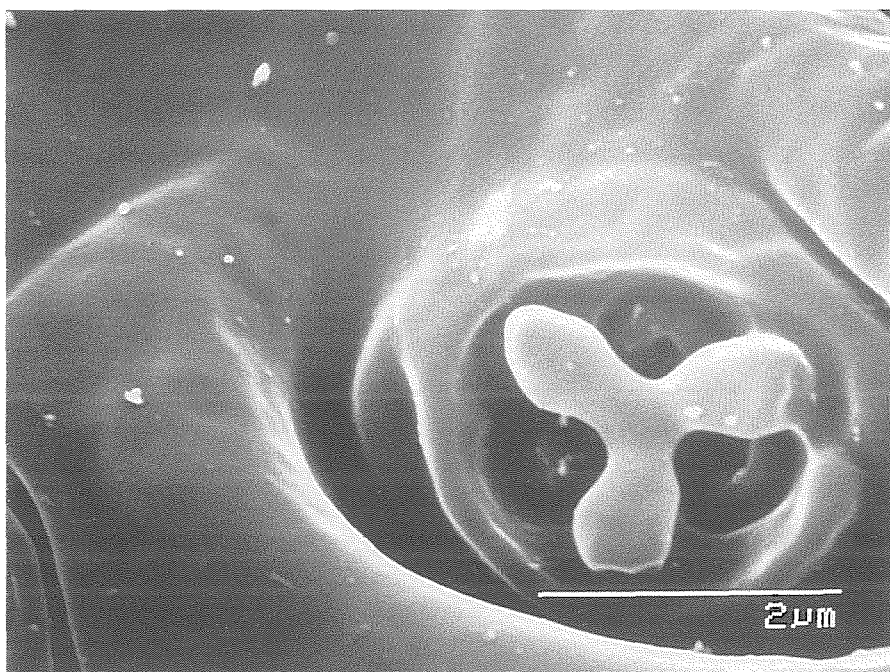


Fig. 36. *Sclopetaspis danumensis*, adult female : anterior spiracular disc pore.

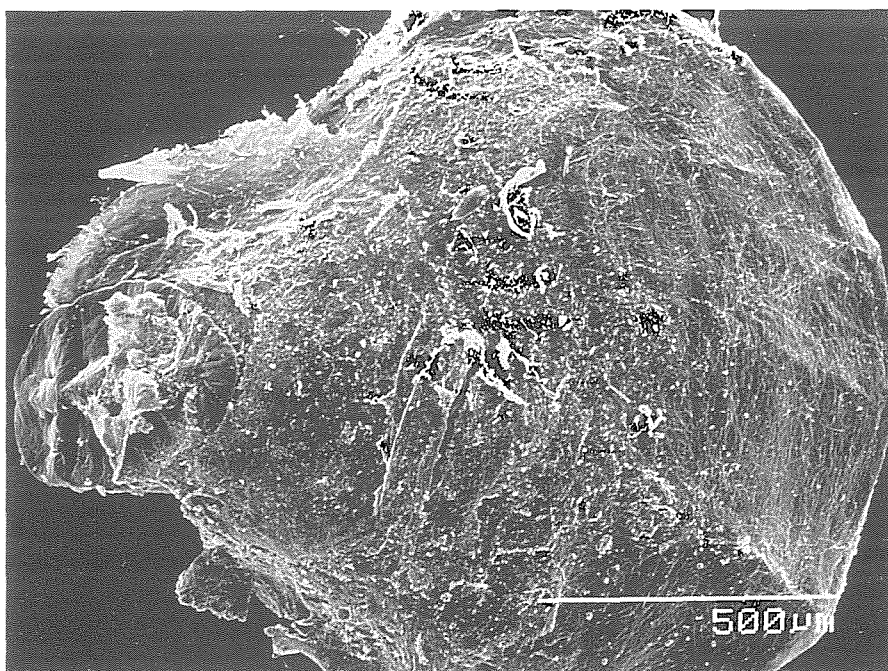


Fig. 37. *Mitulaspis malayana*, female test : dorsal view [90ML-21].

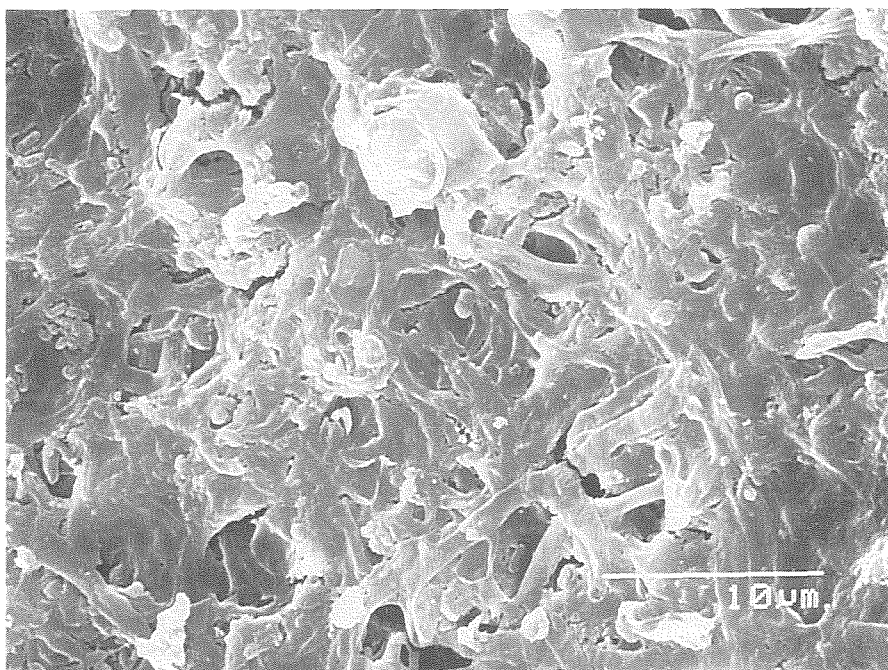


Fig. 38. *Mitulaspis malayana*, female test : dorsal surface (part of Fig. 37).

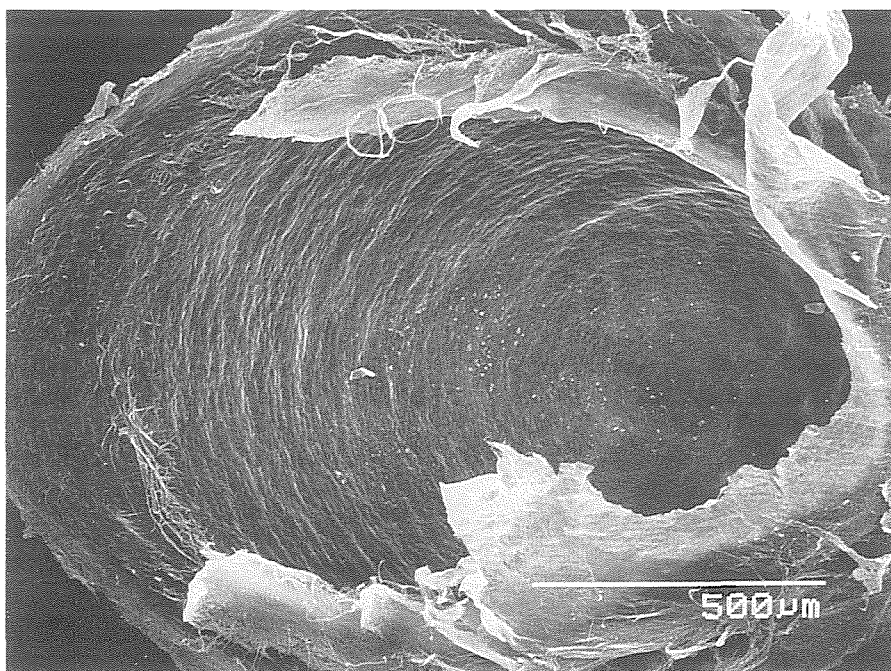


Fig. 39. *Mitulaspis malayana*, female test : inner surface [90ML-21].

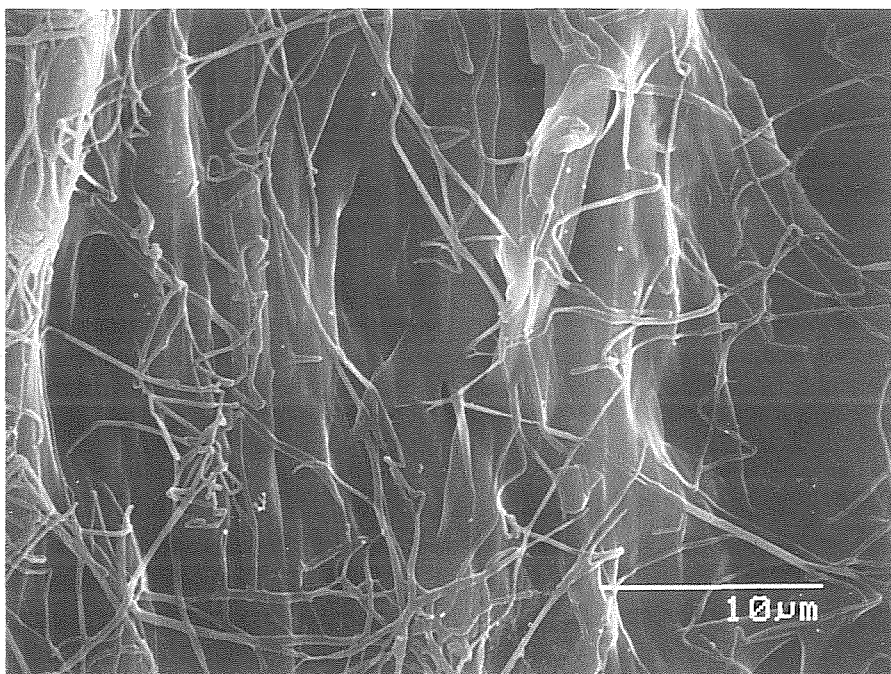


Fig. 40. *Mitulaspis malayana*, female test : inner surface (part of Fig. 39).

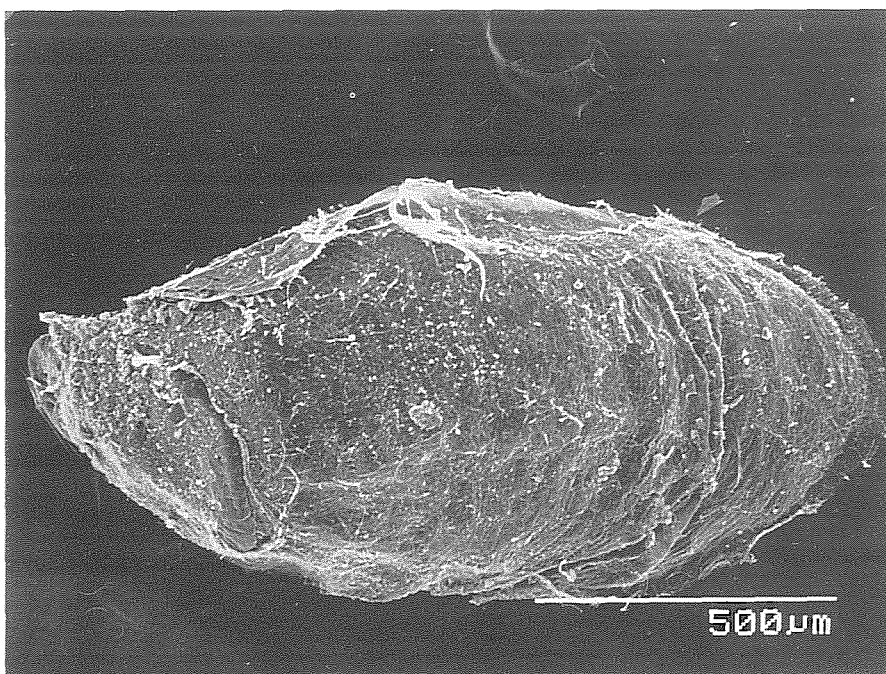


Fig. 41. *Mitulaspis malayana*, male test : dorsal view [90ML-21].

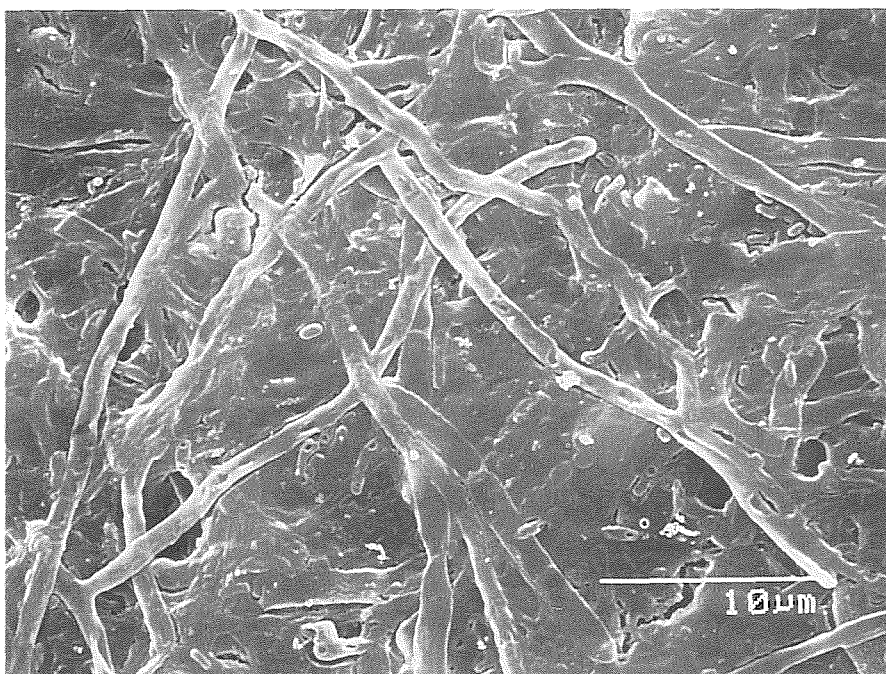


Fig. 42. *Mitulaspis malayana*, male test : dorsal surface (part of Fig. 41).

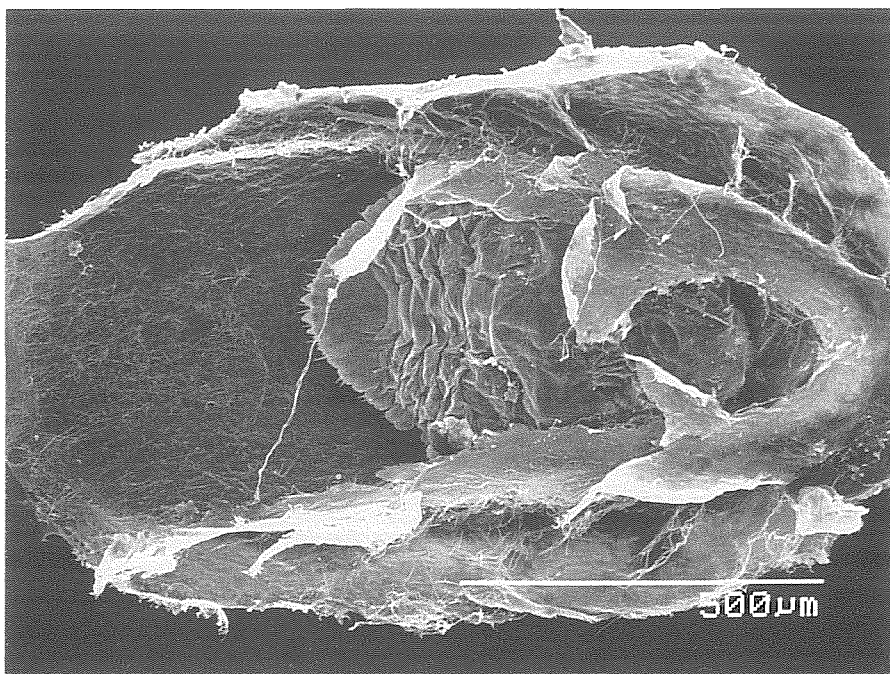


Fig. 43. *Mitulaspis malayana*, male test : inner surface [90ML-21].

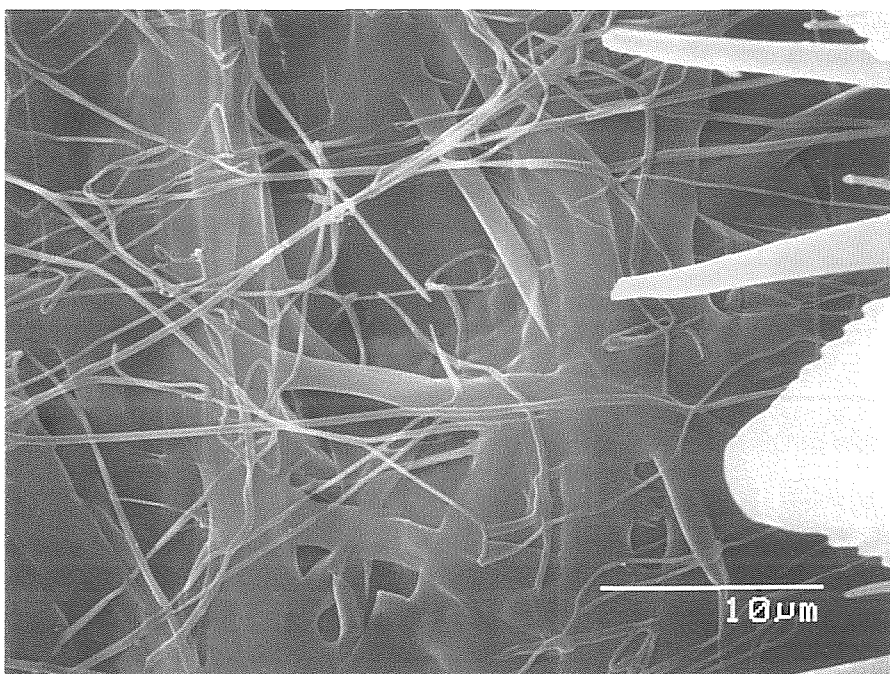


Fig. 44. *Mitulaspis malayana*, male test : inner surface (part of Fig. 43).

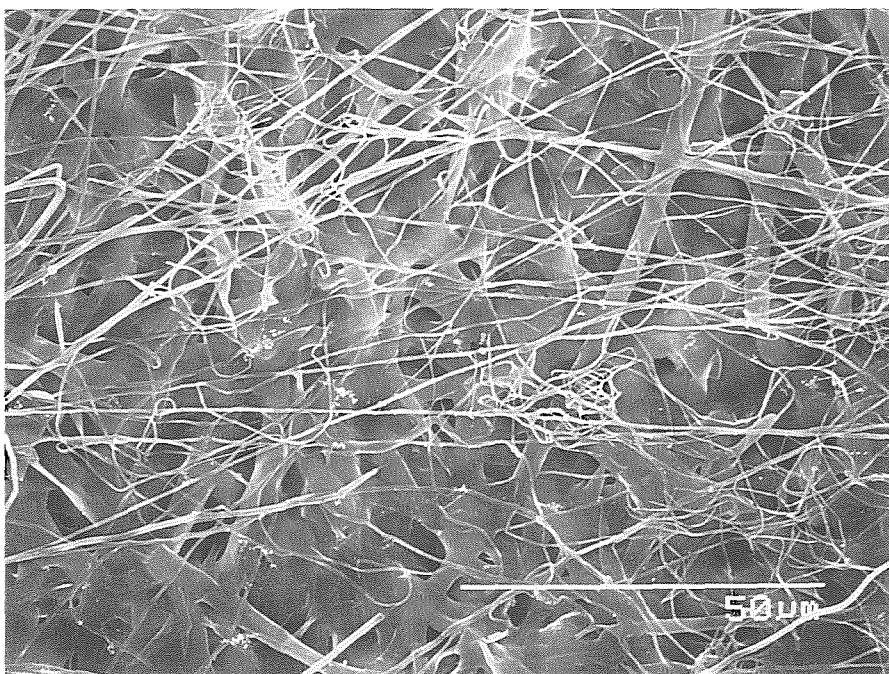


Fig. 45. *Mitulaspis malayana*, male test : inner surface (part of Fig. 43).

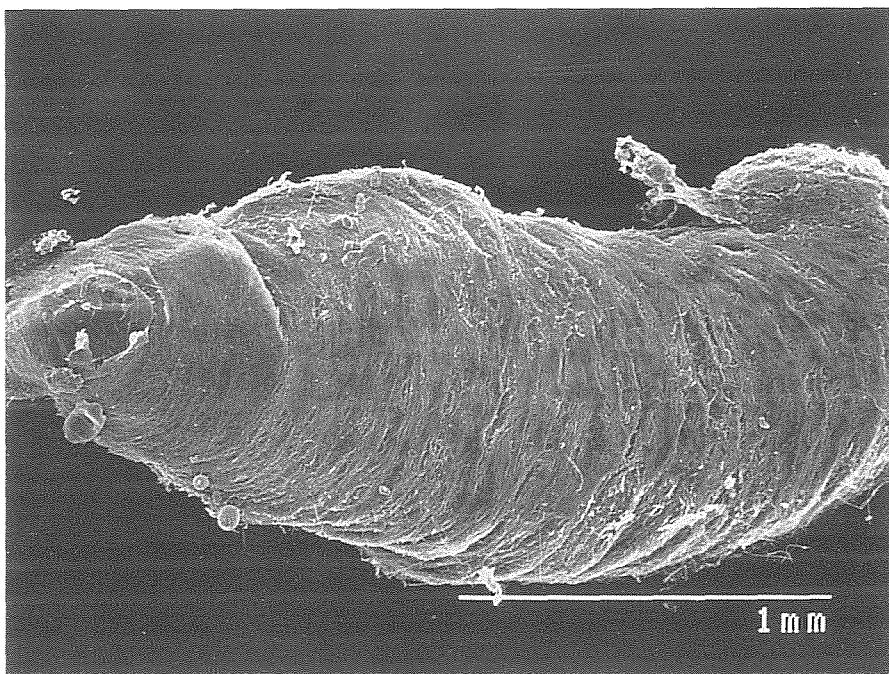


Fig. 46. *Melayumytilus smilacis*, female test : dorsal view [86ML-378].

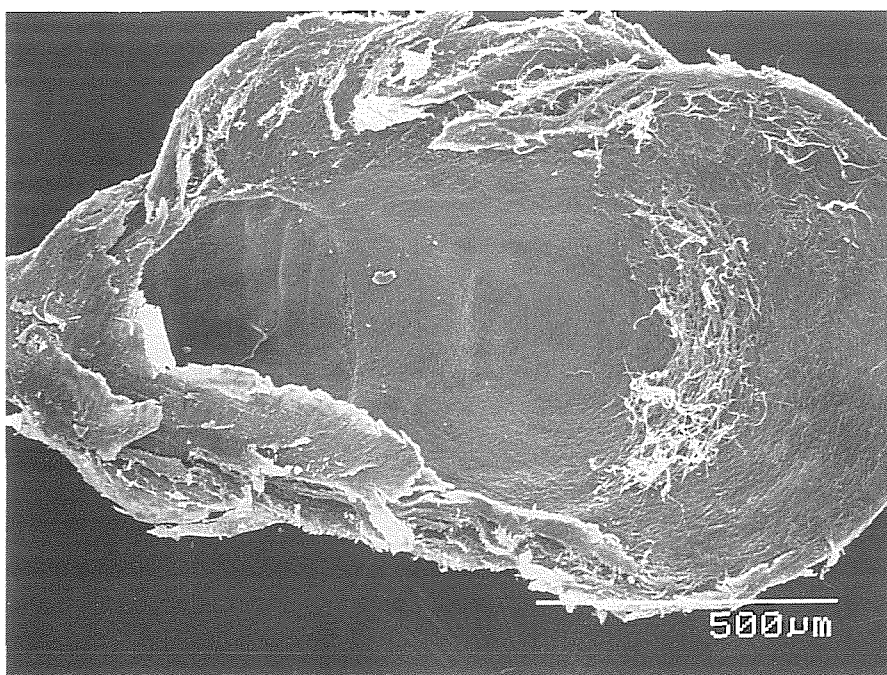


Fig. 47. *Melayumytilus smilacis*, female test : inner surface [86ML-378].

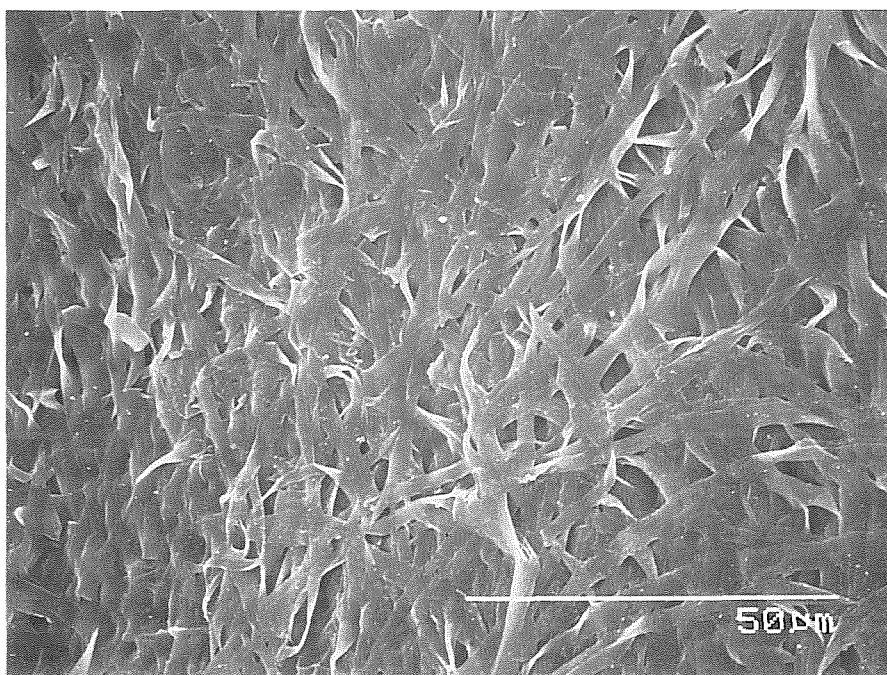


Fig. 48. *Melayumytilus smilacis*, female test : inner surface (part of Fig. 47), near posterior end of test.

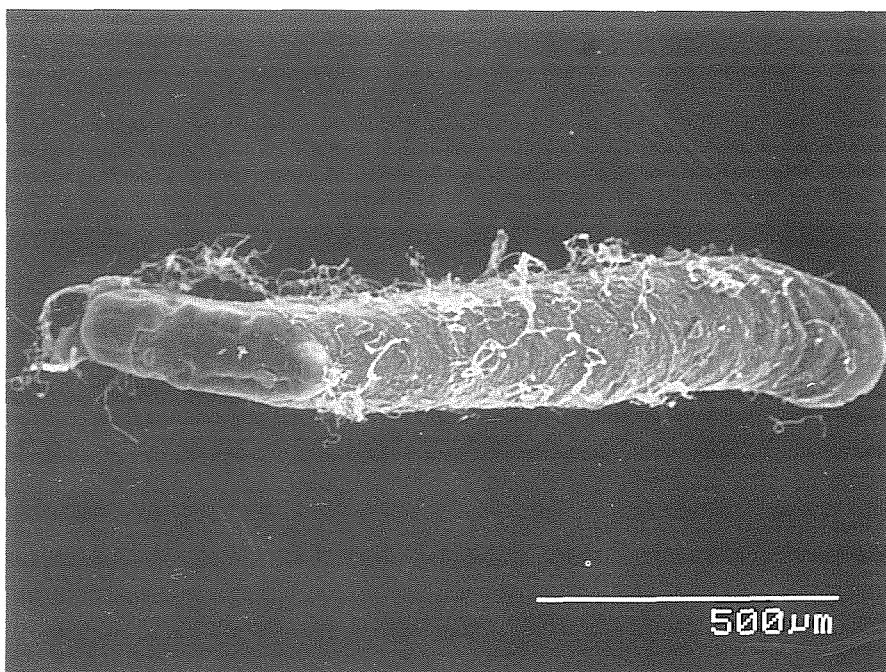


Fig. 49. *Metandaspis javanensis*, female test : dorsal view.

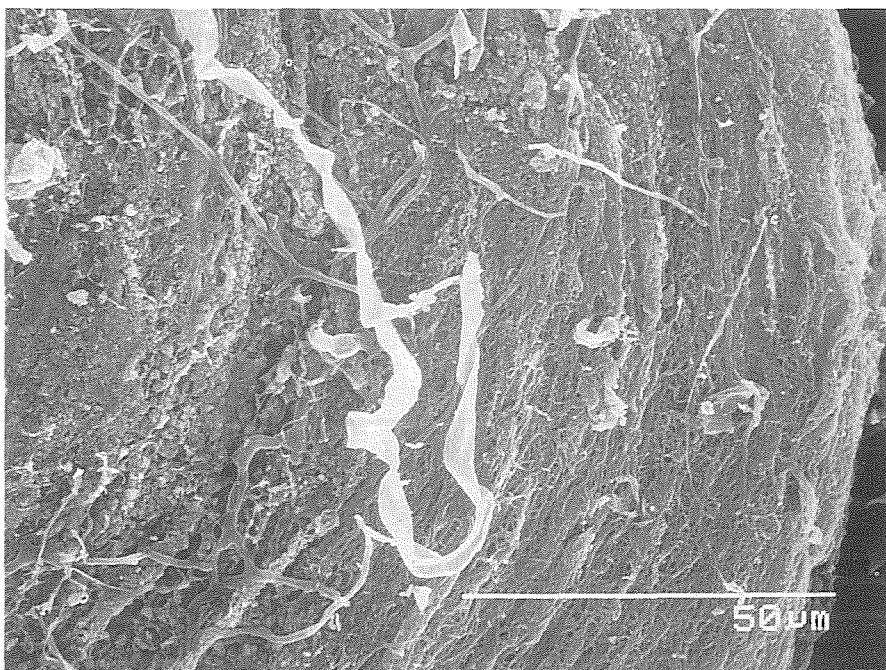


Fig. 50. *Metandaspis javanensis*, female test : dorsal surface (part of Fig. 49), posterior end of test.

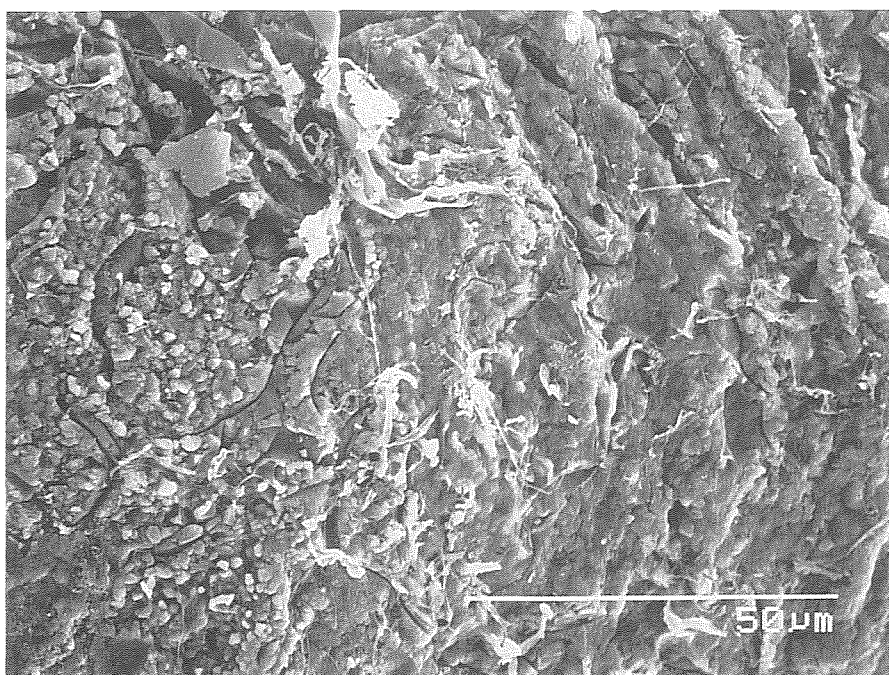


Fig. 51. *Metandaspis javanensis*, female test : dorsal surface (part of Fig. 50).

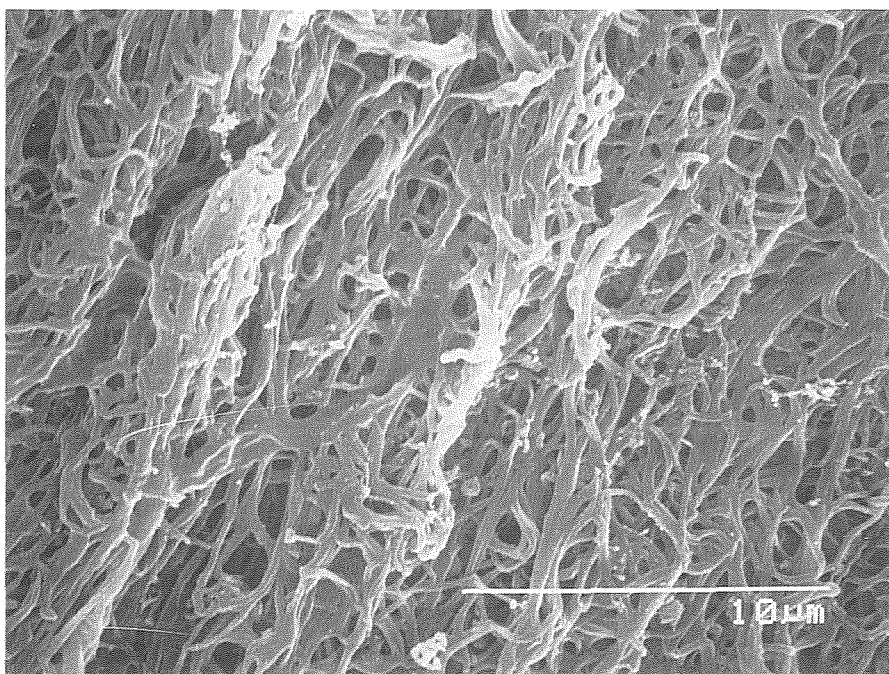


Fig. 52. *Metandaspis javanensis*, female test : dorsal surface (part of Fig. 50), near posterior extremity of test.

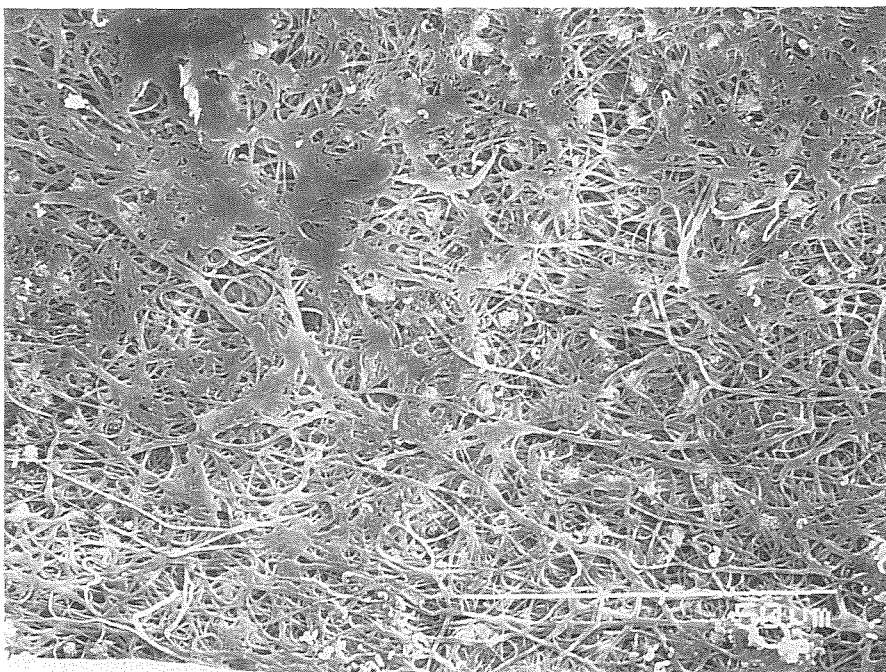


Fig. 53. *Metandaspis javanensis*, female test : inner surface.

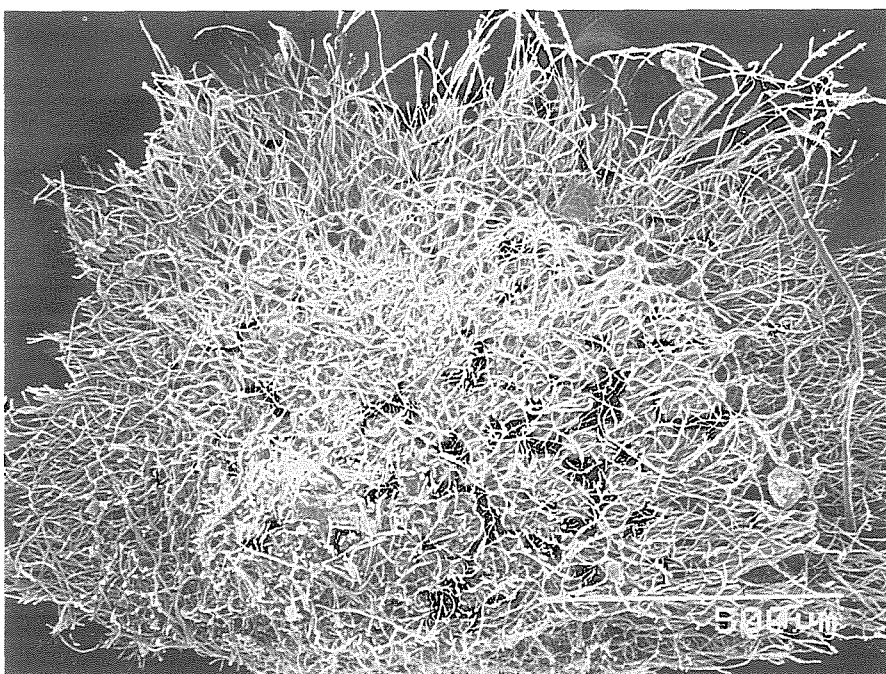


Fig. 54. *Scolopetaspis danumensis*, female test : dorsal view.

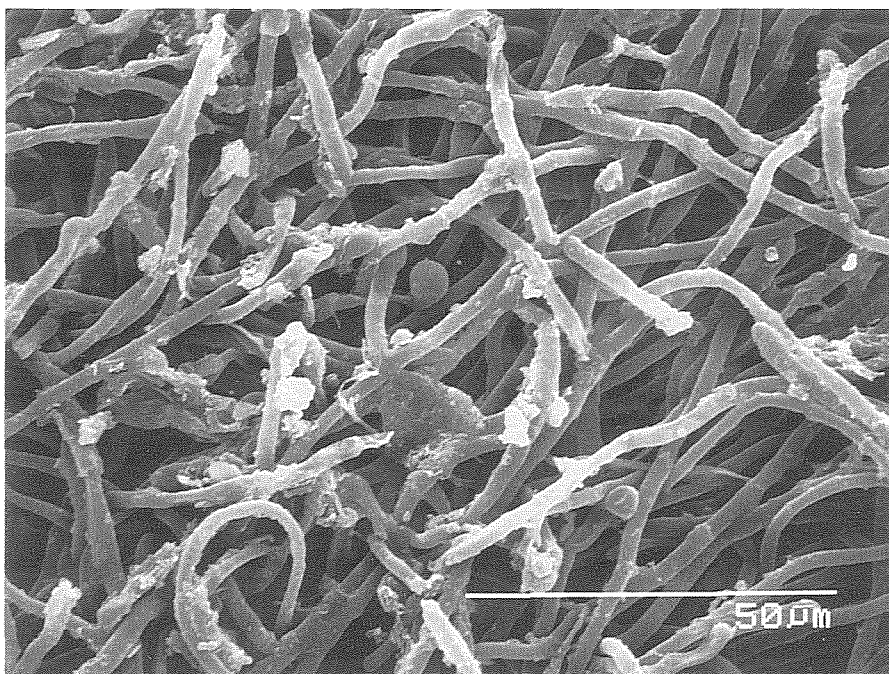


Fig. 55. *Scolopetaspis danumensis*, female test : wax filaments (part of Fig. 54).

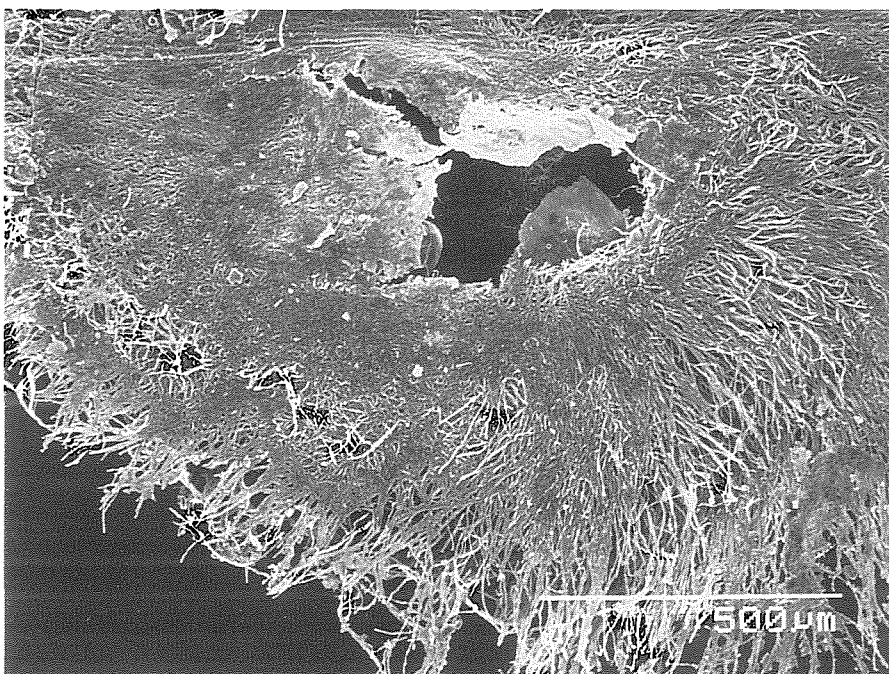


Fig. 56. *Scolopetaspis danumensis*, female test : ventral view.

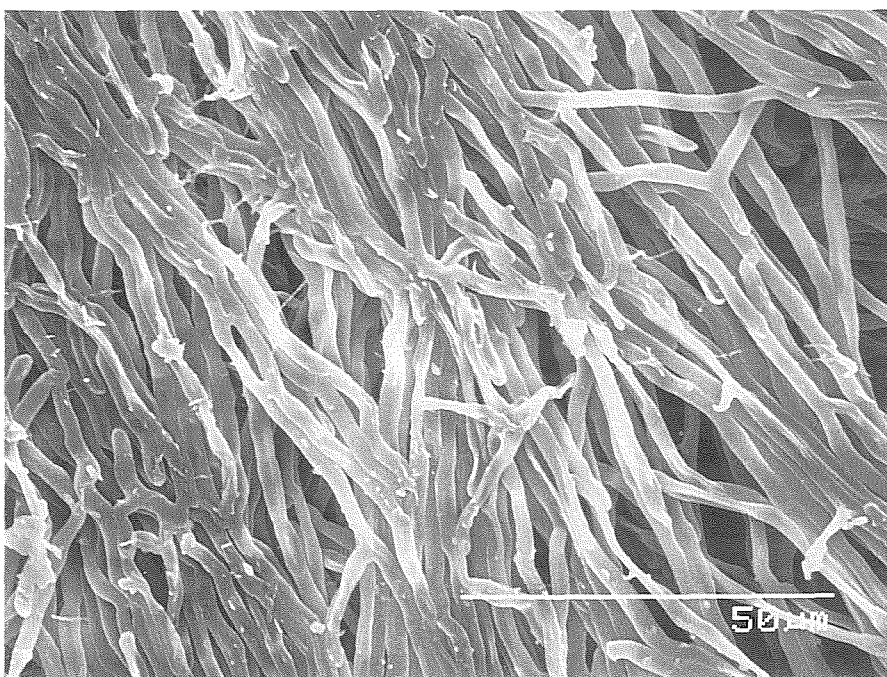


Fig. 57. *Scolopetaspis danumensis*, female test : wax filaments (part of Fig. 56).

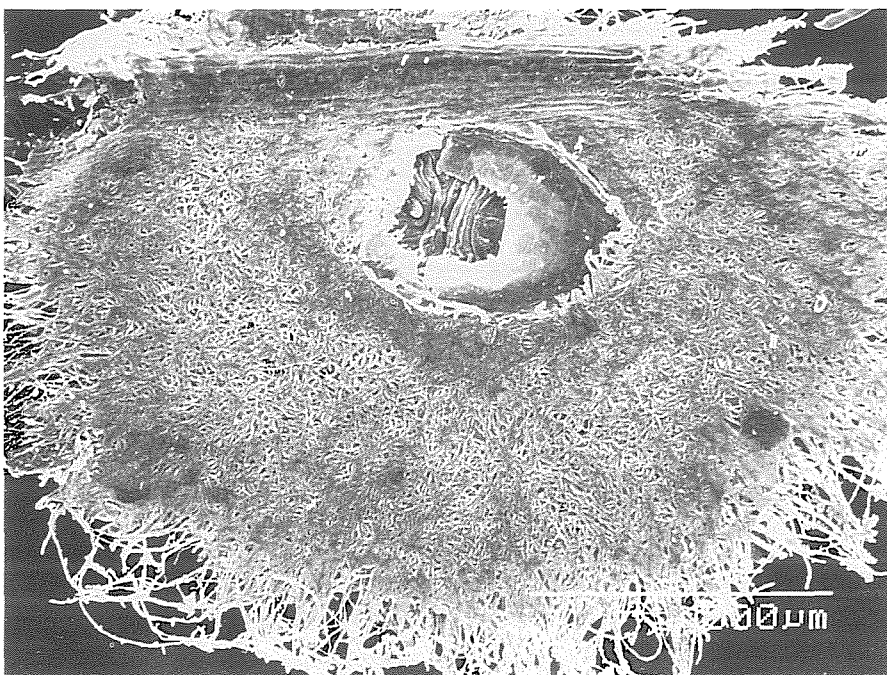


Fig. 58. *Scolopetaspis danumensis*, female test : ventral view.

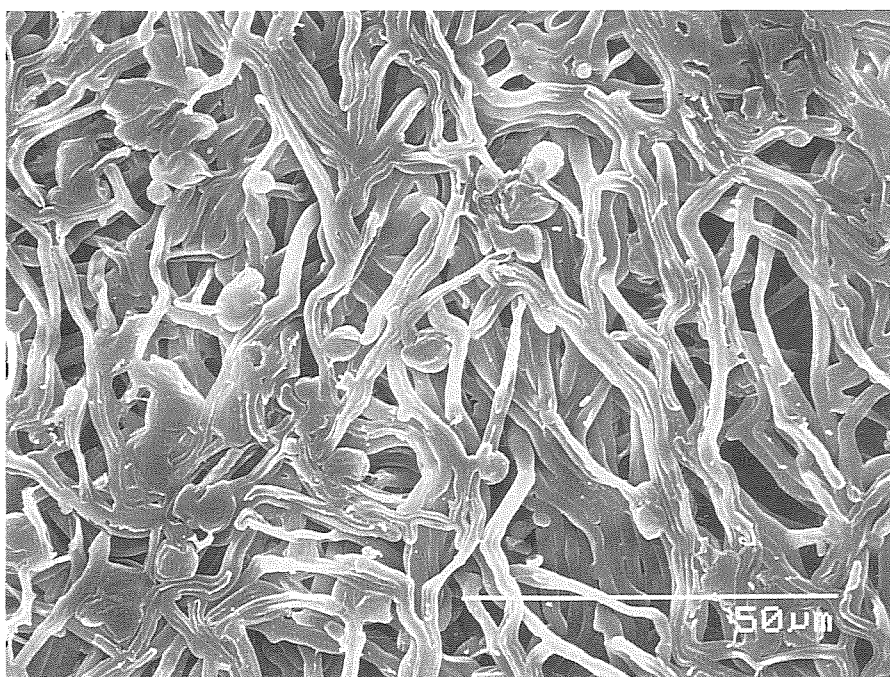


Fig. 59. *Scolopetaspis danumensis*, female test : wax filaments (part of Fig. 58).

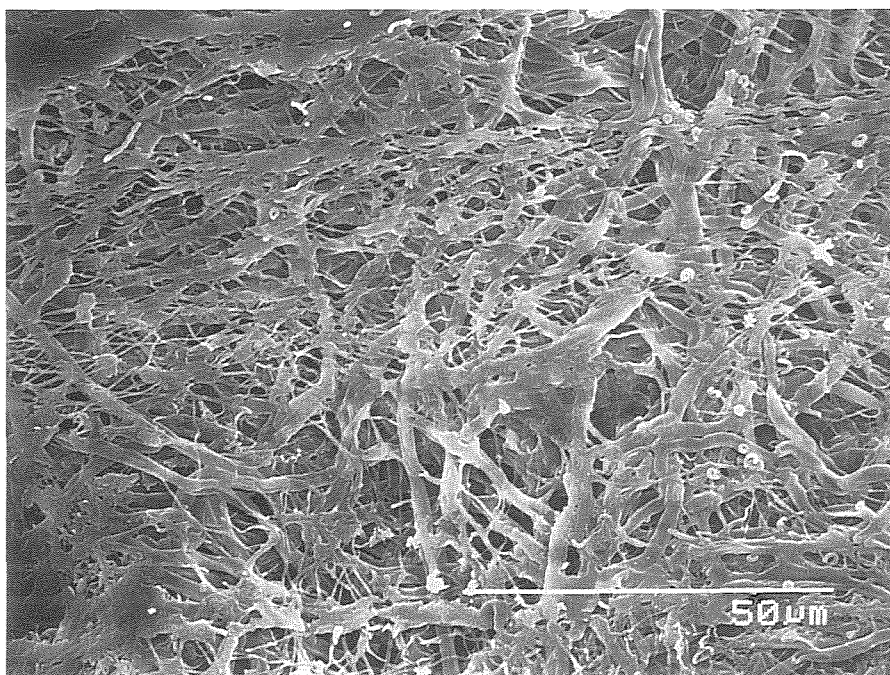


Fig. 60. *Scolopetaspis danumensis*, female test : inner surface of dorsal portion.

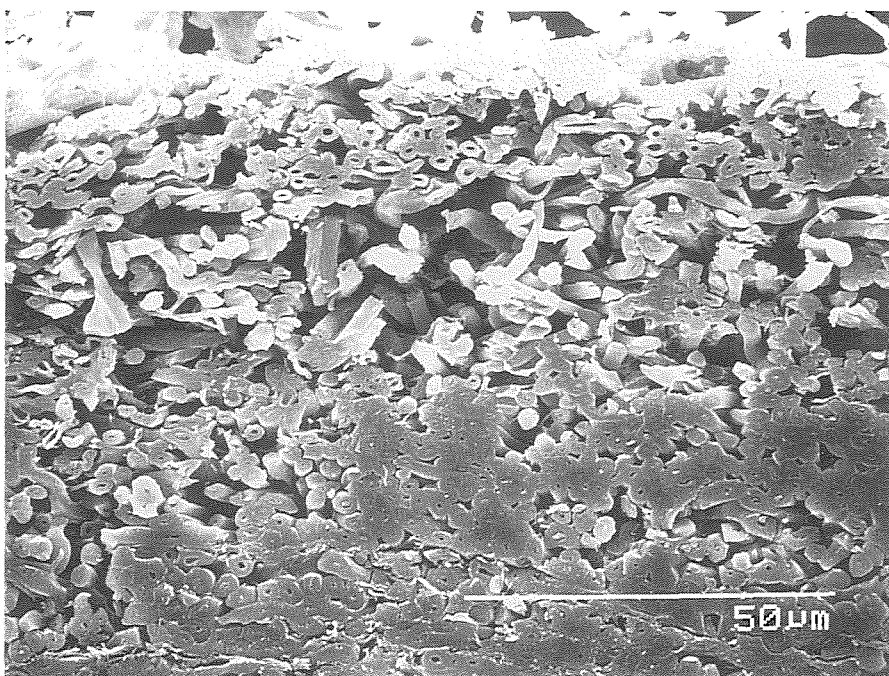


Fig. 61. *Scolopetaspis danumensis*, female test : transverse section of dorsal portion.

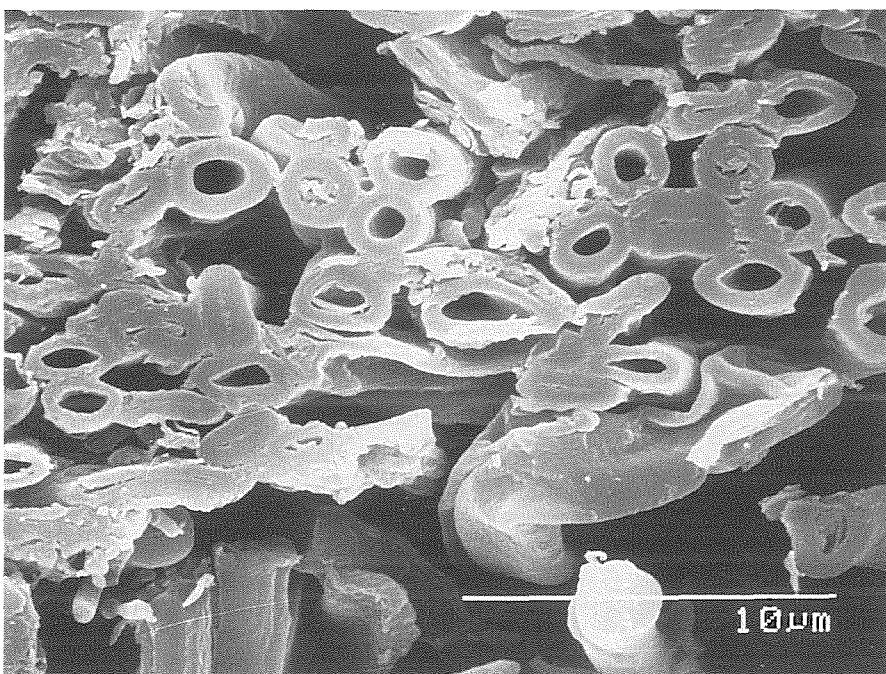


Fig. 62. *Scolopetaspis danumensis*, female test : wax tubes (part of Fig. 61).

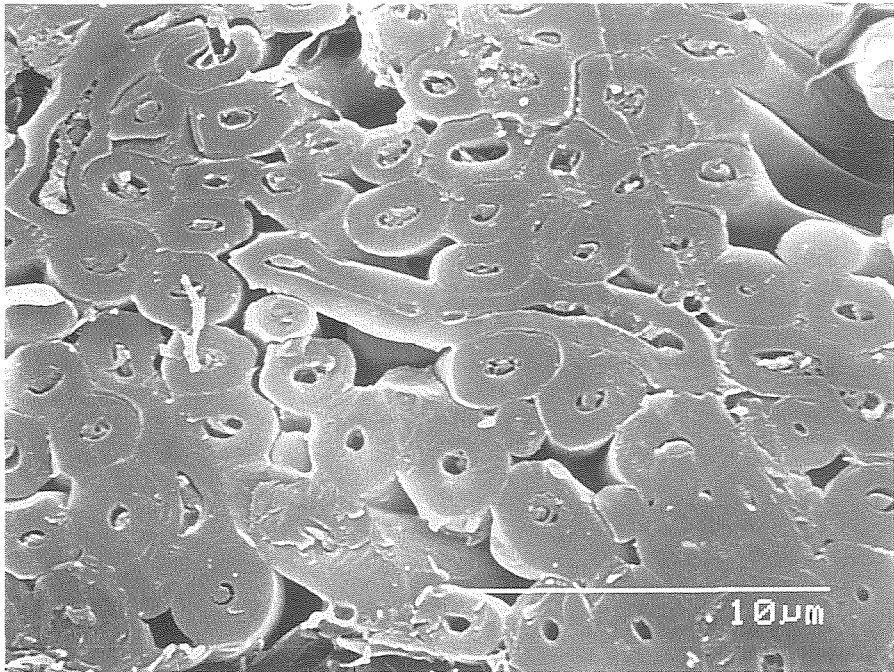


Fig. 63. *Sclopetaspis danumensis*, female test : wax tubes (part of Fig. 61).

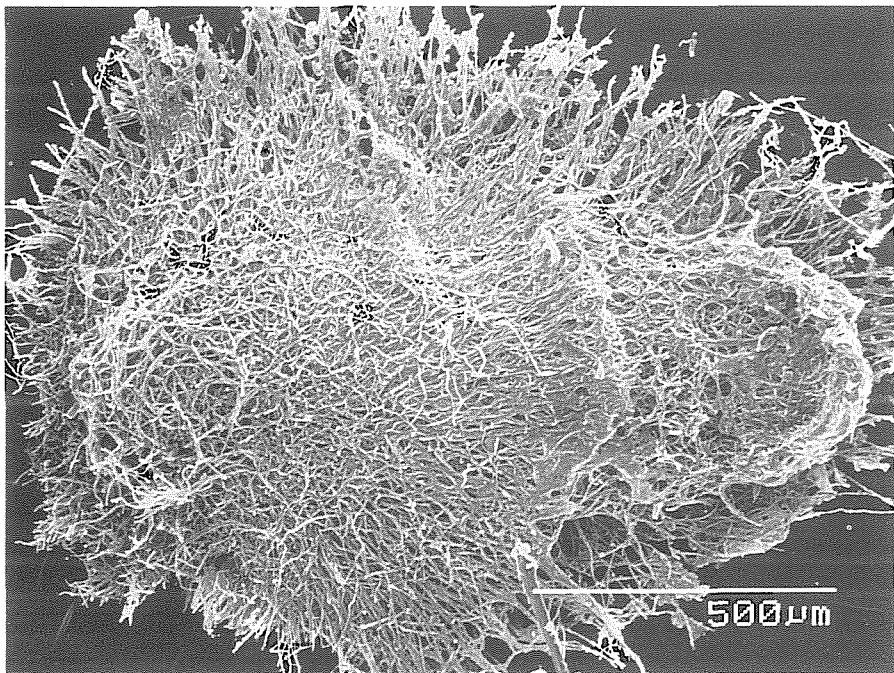


Fig. 64. *Sclopetaspis danumensis*, male test : dorsal view.

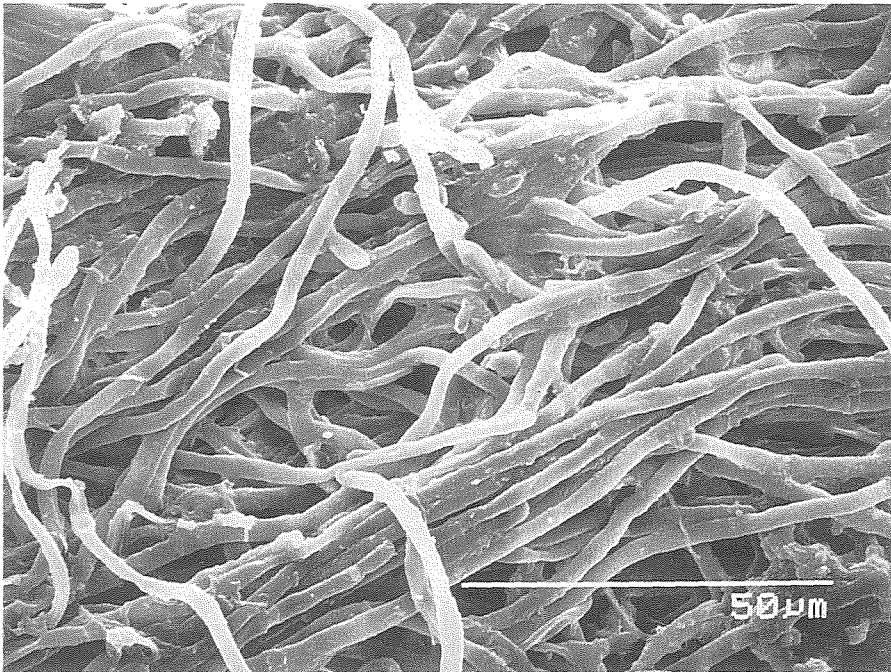


Fig. 65. *Scolopetaspis danumensis*, male test : wax filaments (part of Fig. 64).

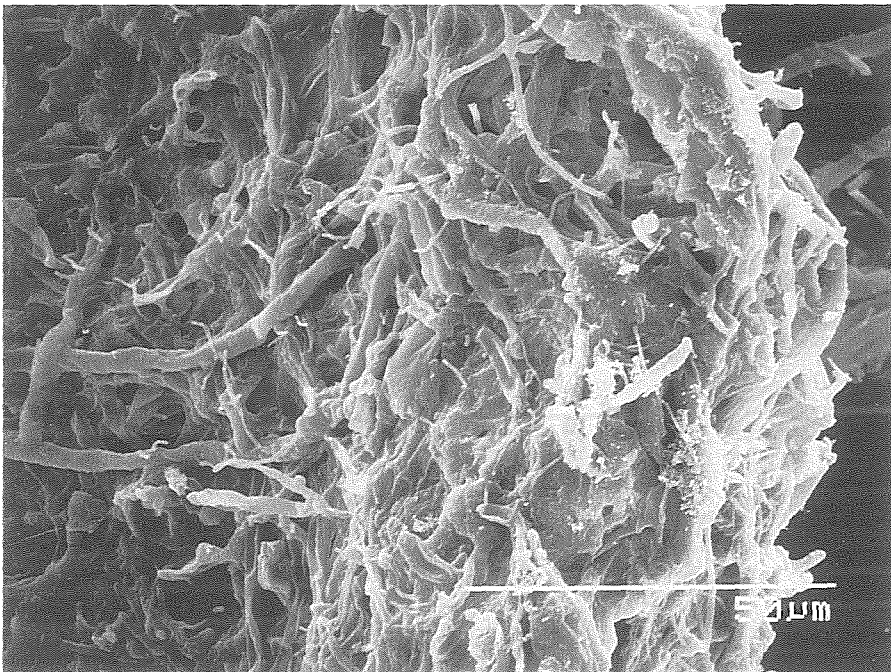


Fig. 66. *Scolopetaspis danumensis*, male test : posterior end. Note that wax filaments are agglutinated together.

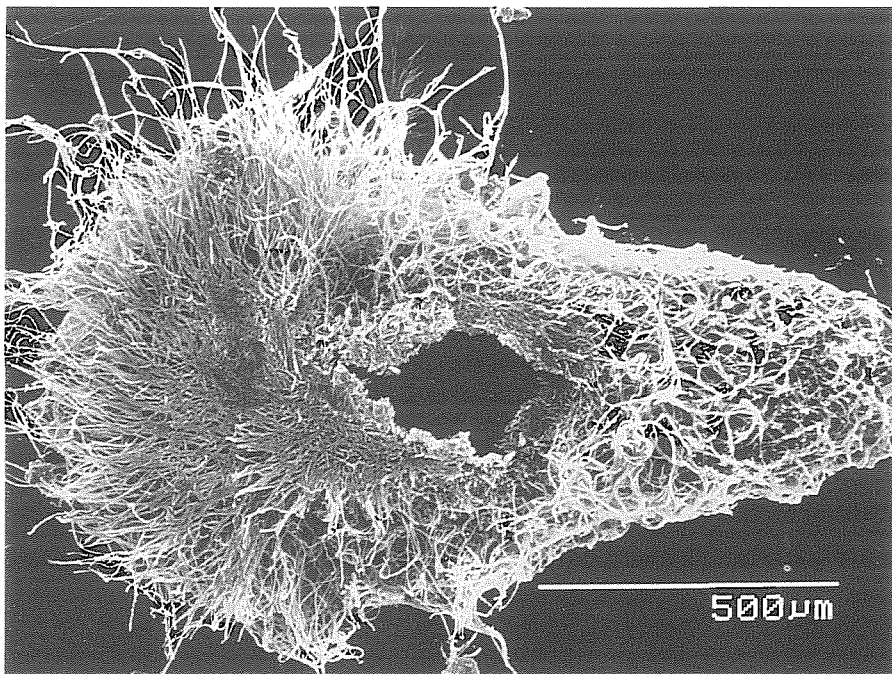


Fig. 67. *Sclopetaspis danumensis*, male test : ventral view.

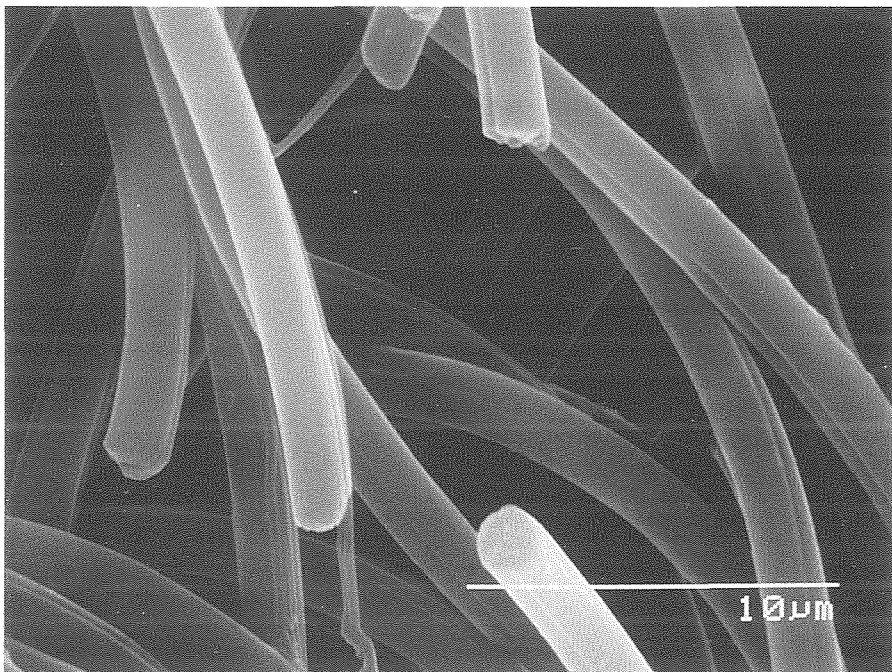


Fig. 68. *Ulucoccus gombakensis*, female test : wax filaments [88ML-338 : Ulu Gombak, Selangor, Malaya, on *Gigantochloa scortechinii*].